Instruments

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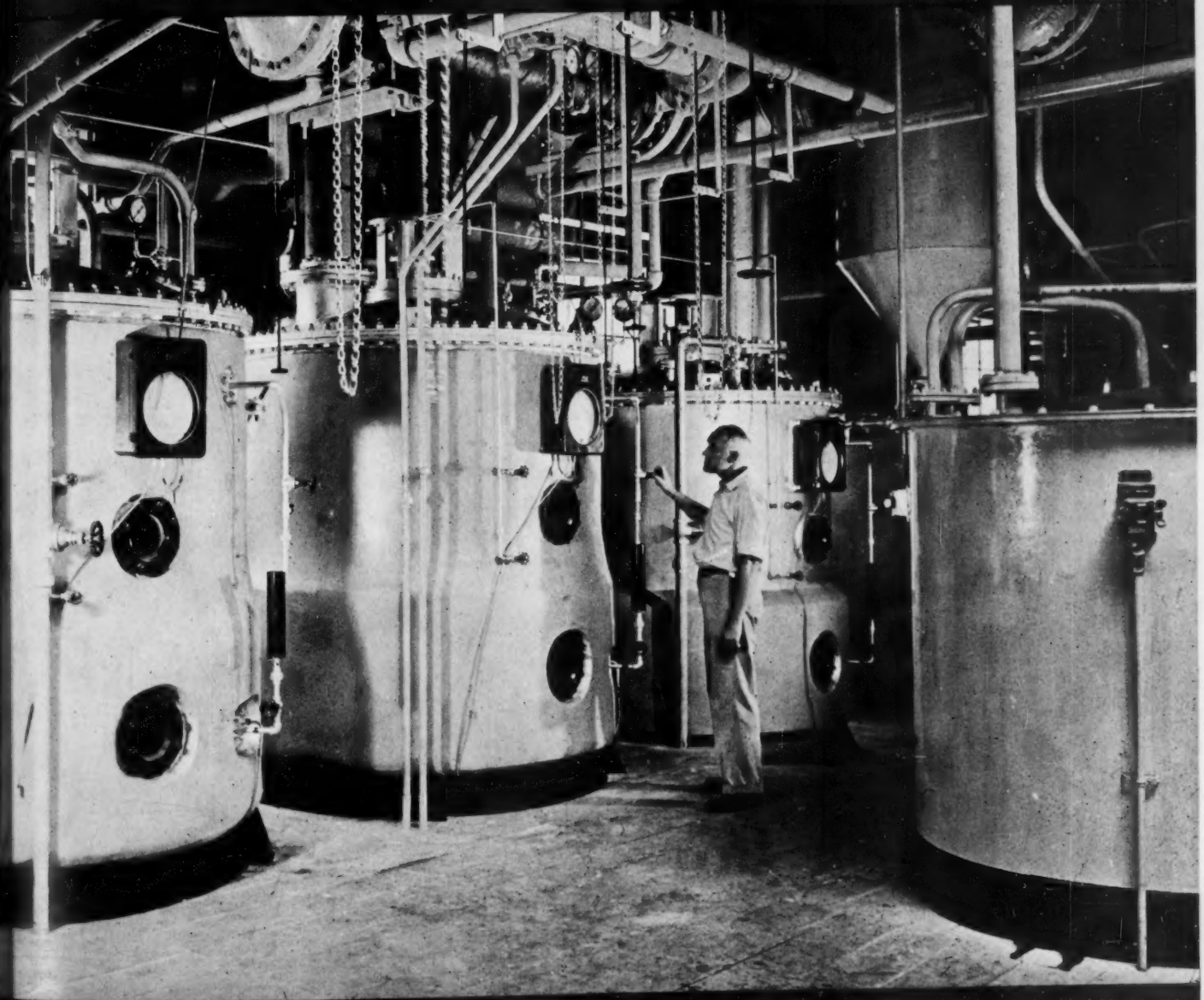

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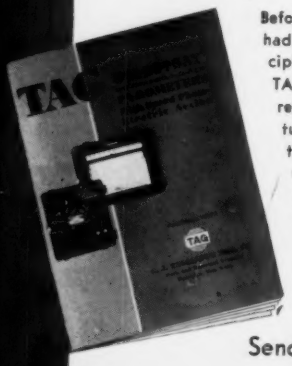

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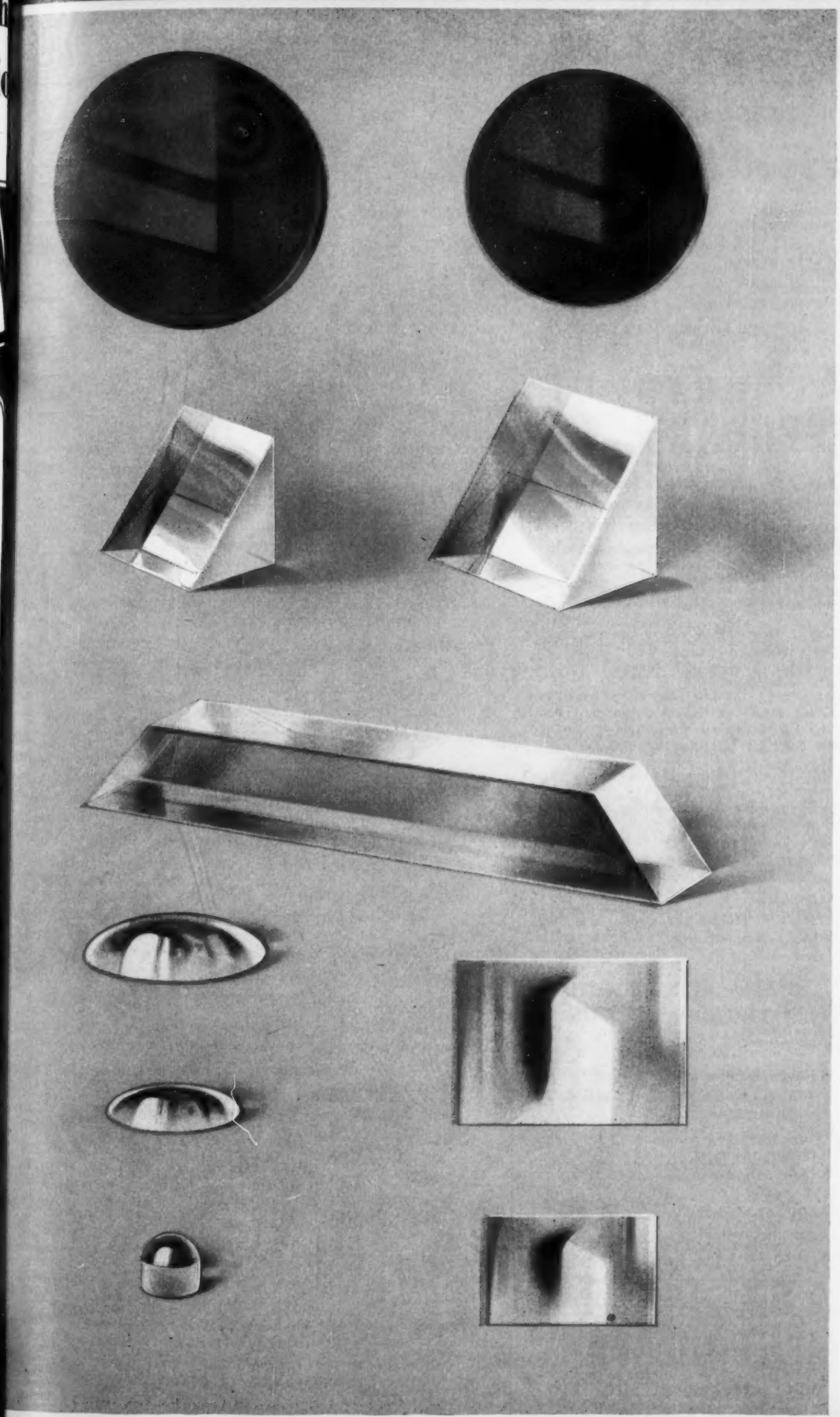

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Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

An Automatic-control "Mystery"?

JUST two years ago, in February 1941, a subscriber who at the time was connected with a famous biological laboratory in Massachusetts wrote me a not-for-publication letter making statements that mystified me and aroused my curiosity. Extracts:

"The instalments of your book 'Temperature Measurement and Control' in the last four issues of 1940 were helpful to me in my work but I take exception to your broad statement that 'No controller can be better than its primary measuring element.' . . . My method of control enables a temperature to be maintained within much narrower limits than the primary element is capable of detecting . . . It would be difficult for me to prepare this for presentation in writing . . . I have endeavored to interest a number of persons but it just doesn't seem to take . . . Please advise how I should proceed, with due regard to my interests."

Naturally, I wrote back that he should "tell the world about it; just write it up any old way . . . I find it difficult to believe that what you've got is exactly what you claim . . . A controller cannot possibly maintain the controlled variable within smaller limits than the value of the ultimate sensitivity of its primary element . . ."

Extracts from his reply: ". . . This is the first encouragement that I have yet received concerning this method of temperature control. . . . I shall endeavor to write it up and forward it to you at the first opportunity. . . . You state [see above]. Very well, using this method, we can then regulate to 1/10 or 1/100 of the primary-element ultimate sensitivity. I have an obstinate streak . . . Of course I may be 'all wet' but I am willing to take a chance . . . overwhelming confidence in the favorable result."

I filed this correspondence under "Future Articles" but I couldn't forget it because of the possibility that not only myself but all others who have written on the theory of automatic control had missed something. It is against our policy to beg would-be authors to hurry up with their contributions (we always have enough manuscripts for the next several months) but I was tempted to make an exception and beg this correspondent "for Heaven's sake send in that description of your revolutionary method. Don't keep the world waiting for your amazing disclosure."

A few weeks ago I met this correspondent at a meeting. He is not yet ready to "tell the world" and that is why I may not divulge his name. Nevertheless, he has kindly permitted me to mention the following facts:

1. A typical application is a bath where germ cultures, etc., must be held at constant temperature.

2. The controller is a laboratory thermoregulator with a mercury capillary and platinum contacts, guaranteed to have a differential of less than 0.1° but found by my friend to have a differential or dead zone of only 0.06°.

3. The primary element of this thermoregulator is placed close to the controlled water inlet; the final element of this thermoregulator is placed close to the bath wall. Therefore the thermoregulator has a *negligible dead time* and there is a *negligible application lag.* (Important for the reason expressed in my slogan "Dead times mean dead zones.")

4. The bath temperature is maintained within better than the 0.06° differential: it is actually maintained to ±0.003°.

There you are, readers!

The first explanation that came to my mind was that the high-precision thermometer with which the amazing constancy of the bath temperature was determined was located at the other end of the bath, where the temperature waves (resulting from the off-and-on mode of control) would be attenuated. My friend told me triumphantly that it was not so: the bath was stirred.

Just as we were saying good-bye, I asked him "What kind of a precision thermometer do you use to measure the bath temperature?" He replied that it was a Beckmann type of good make.

Only after I had left him did another possible explanation occur to me: that there are temperature fluctuations equal to or greater than the controller differential, but that these waves are of such *relatively short duration* that they are attenuated—not only through the thin wall of the Beckmann bulb, but (and here is my contention) by reason of the *relatively enormous mass* of the mercury in the Beckmann bulb.

So now I publicly ask my friend (and others who have similar ideas) to substitute for the Beckmann a bare thermocouple or fine-wire resistance element *of extremely low thermal mass,* hooked up to an amplifier and rapid recorder. I think this will disclose that the fluctuations are really greater than the controller's dead zone . . . And yet . . . And yet, my friend impressed me so much with his confidence and sincerity that he may indeed "have something" to startle us old-timers who designed and built our first instruments forty years ago.

There's still another explanation, but it's a matter of process design rather than of instrumentation, so I'll only mention it briefly and in small type. I refer to "make-up tank" or "anticipatory sampling" or "capacitance" arrangements. A crude illustration is this: suppose you have a faulty shower-bath regulator that causes the shower to change rapidly from 80°F. to 100°F. (by "rapidly" I mean the time for one quart to flow) and that you want an even-temperature shower. On the shower head you hang an *eight*-quart can. Around this *two*-gallon can, catching its overflow, you hang a *ten*-gallon bucket with a perforated bottom. If you're exceptionally tall you'll have to stoop, but the *final*-temperature variation will seldom exceed half a degree. (Math sharks: start with a square wave and apply those two capacitances. Or do it graphically.) As to "anticipatory" arrangements, they are well-known in air-conditioning practice, one idea taking the form of a small box on the wall of a large room, said box containing a tiny heating element and a thermostat interlocked with the room thermostat which commands the room-heat supply. I think that such PROCESS-DESIGN ideas do not disprove the truth of my slogan. What do YOU think? —MFB

Cover: Fermentation

FOR perhaps the first time, the orchid of an *Instruments* cover photo and write-up is bestowed on a fermentation process. . . . The importance of industrial fermentation plants is growing with an acceleration comparable to that of the processes themselves as "stepped up" by the use of new organisms, new control techniques, etc. Believe it or not, biochemists now distinguish between male and female yeasts! It won't be long before Jack's bean-stalk is outdone—in a volumetric way if not vertically!

Instrumentation plays a part in these modern processes and is utilized by Chas. Ffizer & Co., Inc., whose products include citric acid, gluconic acid, fumaric acid and oxalic acid, and whose Information Manager, W. H. Staebner, sent us the photograph and wrote:

"On the front of each vertical evaporator is a two-pen recording thermometer made by C. J. Tagliabue Mfg. Co. One pen records the batch temperature, the other the temperature of the used condensing water, enabling a close economy in the use of water.

"At the top of each vertical evaporator are two Ashcroft gages, one for pressure and one for vacuum.

"On the vertical tank at the right of the picture is shown an explosion-proof switch made by the Allen Bradley Co."

A New Electronic Relay Method

By JOSEPH RAZEK, Consulting Physicist, C. F. Burgess Laboratories, Inc., Elgin, Ill.

ONE of the first applications of the electronic tube, outside of communications work, has been its use as a relay. The remarkable property of a triode of controlling relatively large amounts of power in the plate circuit, with the expenditure of an extremely small amount of power in the grid circuit, was soon applied to many uses. However, the amount of power which can be handled in the plate circuit of the smaller vacuum tubes is generally so small that mechanical relays of the usual kind were still required. With the development of the grid-controlled gas-filled rectifier tube —the Thyratron—the situation was somewhat changed. In these tubes, the plate current is greater than that in the high-vacuum tube. Even the smallest tubes will pass currents of around 0.1 amp. and moderate-size tubes, which will pass currents of one to ten amperes, are readily available. A further advantage of this type of tube lies in the fact that the tube has a more nearly true "trigger" action. That is, as the grid potential changes, up to a certain value, nothing happens, and then a small change, generally a fraction of a volt, will cause the maximum plate current to flow. This snap action is generally a desirable characteristic in most relay operations. This trigger feature, however, brings in other complications such as the fact that generally the tube must be extinguished by some extraneous means. These features have been discussed in many articles and papers dealing with the applications of these tubes. There are in daily use a large number of devices which make use of these tubes in a wide variety of applications. The majority of the arrangements have had to be especially designed and engineered for the specific application in mind.

To avoid the necessity for such special designing and engineering is the chief object of the new method here described. This method is based on the use of a multi-purpose unit serving as an intermediate link between the actuating device and the output without any alteration.

In addition to taking advantage of the usual properties of the grid-controlled rectifier tube, a further unique feature of this method lies in the fact that the operating output circuit current does not pass directly through the grid-controlled rectifier tube. Instead, a special transformer is used. In this transformer the impedance of the coil which is to carry the output current is altered greatly by the degree of saturation of the iron core. This degree of saturation can be controlled neatly by means of a much smaller current flowing through a large number of turns wound around the same core. As a fluctuating direct current flows through the coil of a large number of turns, the magnetic core is saturated, thereby reducing the impedance of the other winding and allowing the output current to flow through this winding.

The advantages resulting from the use of the special transformer are that a smaller grid-controlled rectifier tube can be used to control a relatively large amount of power (since the output current never needs to pass through the rectifier tube directly) and that the output circuit gives a better a-c. wave. This would not be the case if the output current passed through the rectifier tube. In the latter case, the best which could be obtained would be to have a pulsating direct current. Although such a current can be made to operate most alternating-current devices, the wave-form occasionally causes some difficulty.

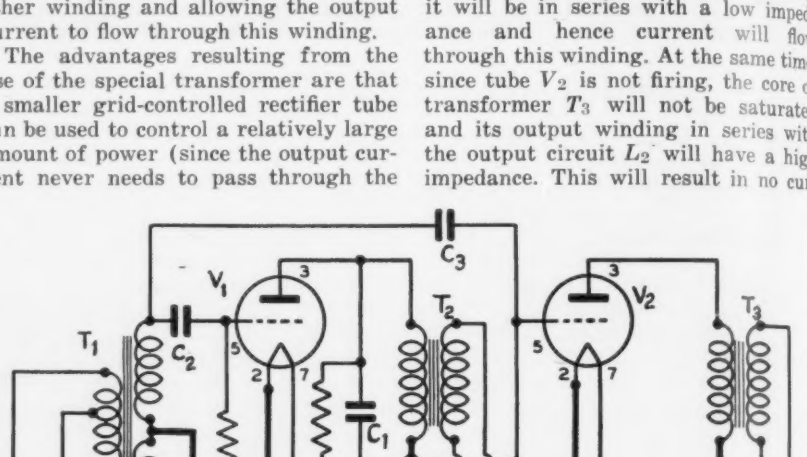


Fig. 1

The wiring diagram is shown in Fig. 1. Transformer T_1 supplies the filaments of grid-controlled rectifier tubes V_1 and V_2. The tube grids are so connected that when one tube fires, the other tube is extinguished. (This results in a sharp off-and-on action in certain applications discussed later.)

When the actuator contacts are closed, ground potential is impressed upon the grid of tube V_1 which causes the plate current to flow through the input winding of transformer T_2. The core of this transformer T_2 becomes saturated, reducing the impedance of the output winding which is in series with the input voltage and the output circuit L_1. Therefore, if a load has been connected across the output circuit L_1 it will be in series with a low impedance and hence current will flow through this winding. At the same time since tube V_2 is not firing, the core of transformer T_3 will not be saturated and its output winding in series with the output circuit L_2 will have a high impedance. This will result in no current (or, at the most, a negligibly low current) flowing through the output circuit L_2.

If now the actuator contacts are opened, the action will immediately reverse since tube V_1 will now have a negative potential applied to its grid causing the tube V_1 to become extinguished.* The plate current of this tube will no longer flow through the winding of transformer T_2 and the impedance of the winding in series with the output circuit L_1 will be greatly increased, reducing the current in the output circuit to a low value. Immediately, the grid of tube V_2 will become positive to a sufficient extent to allow a plate current to flow through the plate winding of transformer T_3, which will then reduce the impedance of the winding of transformer T_3 in series with the out-

*On the reverse part of the cycle when the plate is negative with respect to the cathode, no current would flow in any case regardless of what the potential condition of the grid may be and hence no attention need be paid to this part of the cycle.

put circuit L_2, allowing the current to flow through this output circuit. Owing to the capacitors C_2 and C_3, the action is such that when one tube becomes energized, the other tube becomes de-energized immediately.

To summarize: closing the actuator contacts results in energizing output circuit L_1; opening the contacts results in energizing output circuit L_2 and de-energizing output circuit L_1. When a contact actuator is used, there is no "off" position; i.e., with one output circuit on, the other circuit is off, and the current flowing in the energized output circuit is determined only by the resistance of the output circuit. (The maximum output capacity in a typical commercial unit is forty volt-amperes. This capacity is sufficient for operating a moderate-size reversing motor, heating coils, lights, etc.)

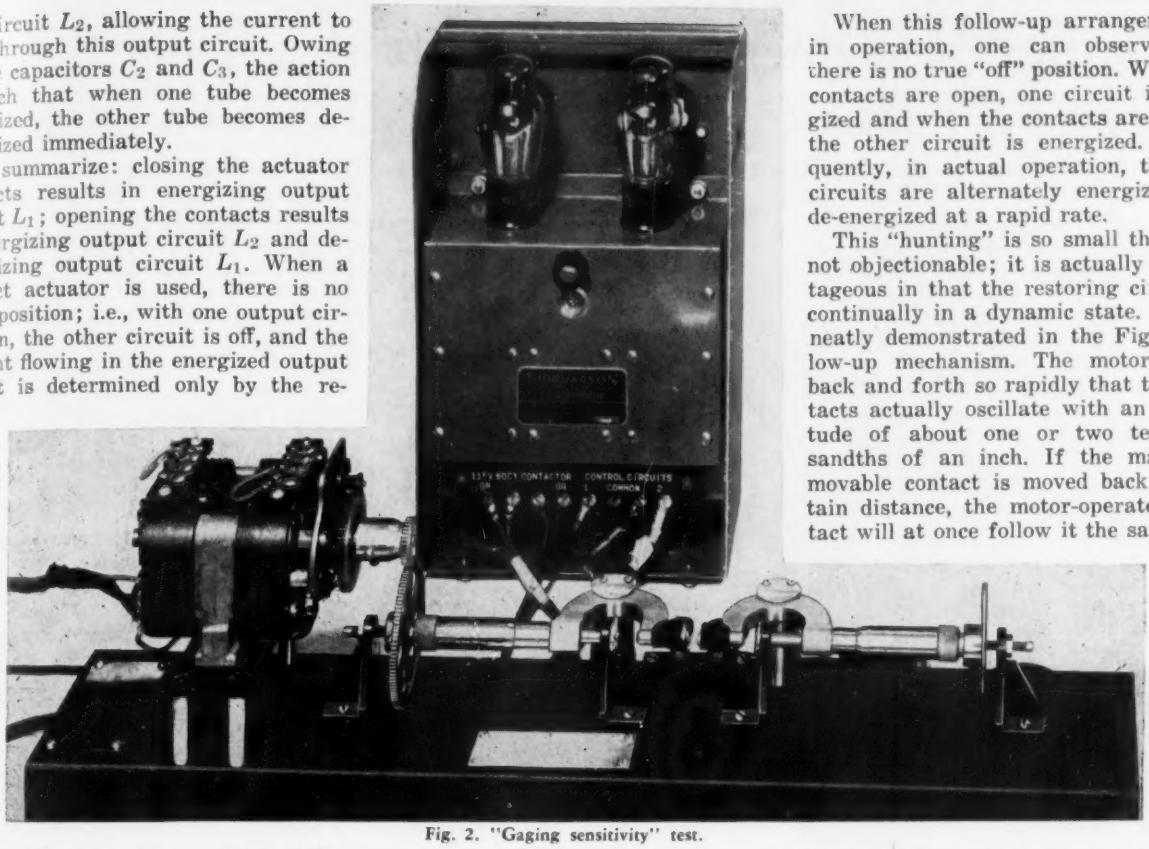


Fig. 2. "Gaging sensitivity" test.

OPERATING CHARACTERISTICS

The original application for which this method was devised was of the type in which the operation was obtained by closing and opening a pair of contacts connected to the actuator. A unit was arranged in which the two contacts could be brought into contact very gradually through a measured distance. One contact was mounted on a rigid base and the other on an extremely accurate micrometer screw. It was found that a sharp break in the circuit, one way or the other, could be obtained by a motion of the contacts of only one ten-thousandth of an inch. That is, the output circuit L_2 would be energized when the contacts were open by only 0.0001". Then moving the contacts 0.0001" to close them would result in energizing the output circuit L_1, and de-energizing the output circuit L_2. Operation is in no wise affected by interposing a resistance up to about 30,000 ohms in series with these contacts. Owing to the fact that this circuit will operate in spite of the large resistance in series with the contacts, the effect of a thin oxide coating on the contacts becomes a matter of relatively little consequence. The materials used for the contacts should be such that a relatively thick non-conducting film cannot be formed over a period of time. It is likely that materials such as stainless steel would be especially useful for this service.

To further study the close operating range of an embodiment of the method, the mechanical follow-up unit shown in Fig. 2 was built. This consists of two micrometer calipers so mounted that the rotation of the barrel will result in a horizontal motion of the yokes. The contacts are mounted on the ends of the yokes. One of the micrometer calipers is arranged to be turned by means of the handwheel; the other micrometer barrel is driven by a reversing motor through a gear. The reversing motor is connected to the output circuits (see Fig. 1) while the contacts are connected to the ends of the yokes. When the contacts are separated, the direction of rotation of the motor is such as to cause the contacts to approach each other. Immediately as contact is made, the motor is reversed and the contacts tend to separate.

When this follow-up arrangement is in operation, one can observe that there is no true "off" position. When the contacts are open, one circuit is energized and when the contacts are closed, the other circuit is energized. Consequently, in actual operation, the two circuits are alternately energized and de-energized at a rapid rate.

This "hunting" is so small that it is not objectionable; it is actually advantageous in that the restoring circuit is continually in a dynamic state. This is neatly demonstrated in the Fig. 2 follow-up mechanism. The motor hunts back and forth so rapidly that the contacts actually oscillate with an amplitude of about one or two ten-thousandths of an inch. If the manually movable contact is moved back a certain distance, the motor-operated contact will at once follow it the same distance and will practically come to "rest" within about 0.0002"; that is, it will oscillate about its final position with an amplitude of about 0.0001". The amount of this hunting is partly determined by the inertia of the rotating parts of the motor. Consequently, for applications in which hunting is to be kept down to a minimum, it is desirable that the motor armature be as light as possible and that the gear ratio between the armature and the moving element carrying the contact be as great as possible consistent with the required operating speed. In the experimental arrangement shown in Fig. 2, the gearing was such that the nominal operating speed of the contacts was about one inch per minute. It is, of course, necessary that the motor used in such an application be so designed that it can operate with full load current passing through the motor

Concluded on page 162

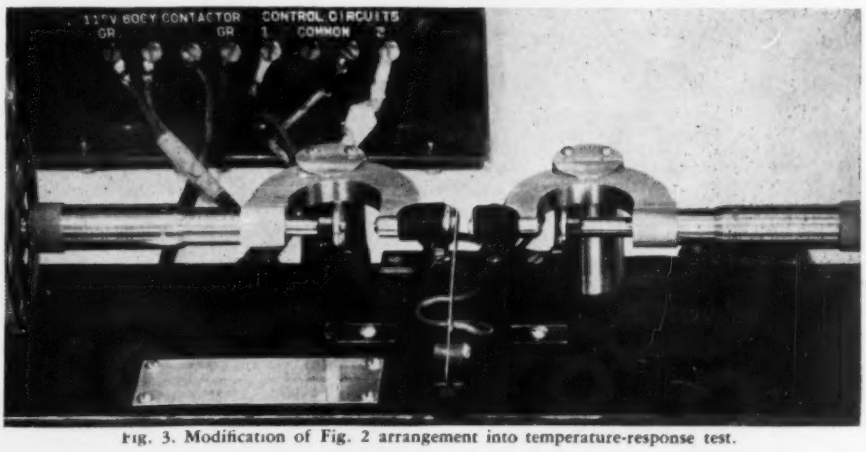


Fig. 3. Modification of Fig. 2 arrangement into temperature-response test.

New Electromagnetic Method of Measuring Screw-thread Leads to a Few Millionths of an Inch

By H. T. RIGHTS, Meter Engineer, Westinghouse Electric & Mfg. Co., Newark, N. J.

UNTIL recently, pitch diameter was considered more important than lead, and there were few lead checking instruments available.

The increase in airplane production, in which threaded parts of close tolerance are used, emphasized the importance of lead. The extensive use of thread plug gages required new instruments to check such gages accurately. As far as we know, there have been no other similar instruments using electrical methods of amplification.

To solve the problem of precise lead measurement, the Sheffield Corp., in coöperation with the instrument engineers of the Westinghouse Electric & Mfg. Co., have developed an electrical lead-measuring method. This method has been embodied in an instrument of the comparator type, shown in Fig. 1, which can be read directly to within 0.00001" and the readings can be estimated to within 0.000001". The method being electrical rather than mechanical, the gaging point functions with a pressure of only three ounces; it has no time lag and is rapid in operation. Anyone experienced in checking thread lead can set up the instrument quickly and operate it successfully.

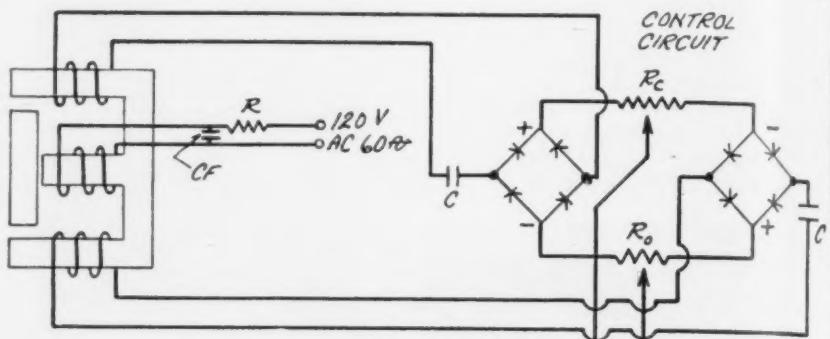


Fig. 2. Functional diagram of electrical thread-lead gage.

The gaging point is placed in contact with the work being tested, the scale pointer of the electrical instrument then indicating near zero. An adjustment on the instrument brings about an exact zero setting.

The heart of the screw-lead gage is the "Electrigage" unit (15). This provides magnification of small displacements of the gaging point by electromagnetic means.

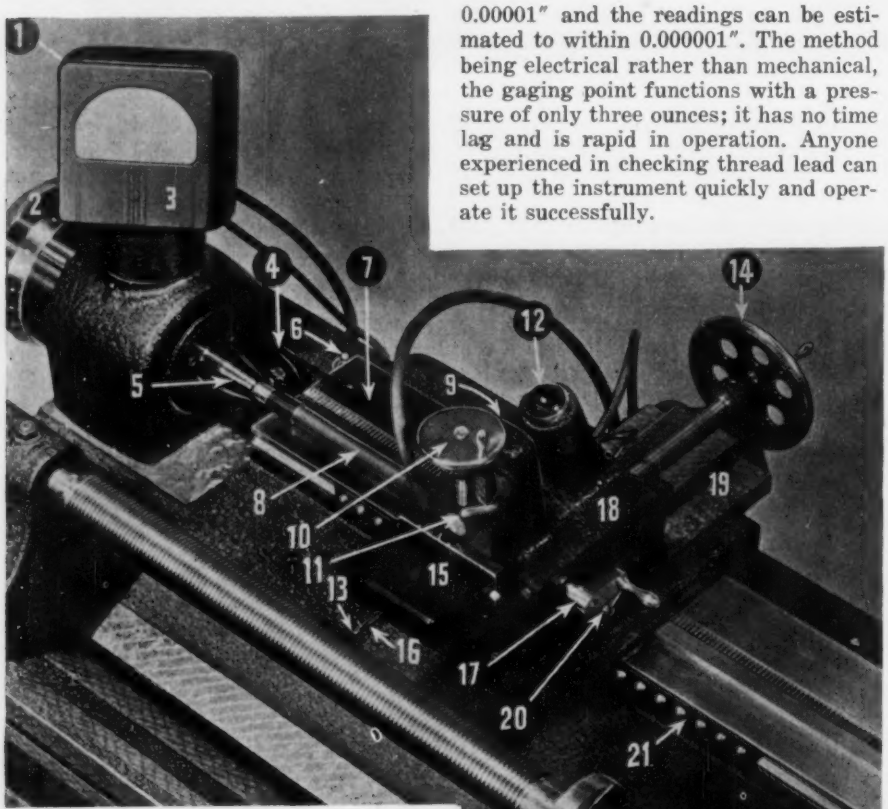


Fig. 1. Details of lead-measuring instrument.
(1) Indicator zero-adjusting wheel
(2) Micrometer dial
(3) Indicator instrument
(5) Micrometer screw
(8) Measuring standard
(10) Vertical slide handwheel
(12) Red safety light
(13) Gage ball point
(14) Base slide handwheel
(15) Electrigage unit
(16) Gage ball point shank
(17) Eccentric lever
(18) Gaging unit
(19) Cross slide
(21) Anti-friction ball slide
(22) Bed of instrument
(23) Tailstock center
(24) Tailstock

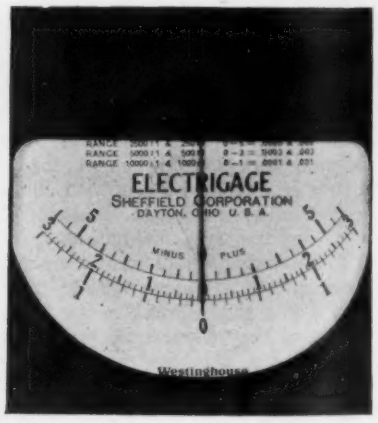


Fig. 3. Detail of Electrigage dial.

Inasmuch as the gage is of the comparator type, reference is made to precision standards of length such as Ford-Johansson or Pratt & Whitney gage blocks (8) and the overall accuracy depends upon such gage blocks. The screw-barrel type super-micrometer (2) reads directly, with 1/16" on its scale

EDITOR'S NOTE—It is more than nineteen years since the appearance of "ultramicrometers" using high-frequency radio circuits with vacuum-tube amplifiers. It is interesting to note the use of commercial frequencies and the absence of electronic devices in some of the new methods.—MFB

being 0.0001". The function of the Electrigage unit is to "micrometer" these divisions so as to read directly to 0.00001" on the instrument dial.

The Electrigage operates on the principle of a balanced magnetic reluctance bridge in which any motion of the armature upsets the balance. The armature is attached to the gaging point (16) which follows the work surface or thread being measured. Fine wire coils wound on branch portions of the magnetic circuit feed the voltages, which are produced by the displacement of the armature, into a special circuit, Fig. 2, which is particularly designed to make indications in linear proportion to the displacements of the armature. This circuit operates on 60-cycle 120-volt a.c., with a power consumption of approximately 15 watts.

In practice, the work is set up so that gaging point (13) engages the work on the pitch line in a plane coincident with the centers (23). The Electrigage is adjusted to the right or left until indicator (3) reads zero. The gaging point is then backed away from the work and moved along to the next thread to be measured, by moving the micrometer dial (2) equal to the nominal dimension of the thread pitch or lead. The gaging point is reinserted into the work and the reading noted on the indicator. The correct reading is the micrometer reading plus or minus the indicator reading. Assurance of correct readings is made by reference to suitable standards such as (8).

The complete equipment is intended to measure screws ranging from 4 to 32 threads per inch. Threads may be tapered or straight, and 12" sections may be gaged at a single setting. The centers will take work up to 30" in length. Longer lengths can be accommodated with vee blocks. Work up to 6" in diameter can be measured easily. See Fig. 4.

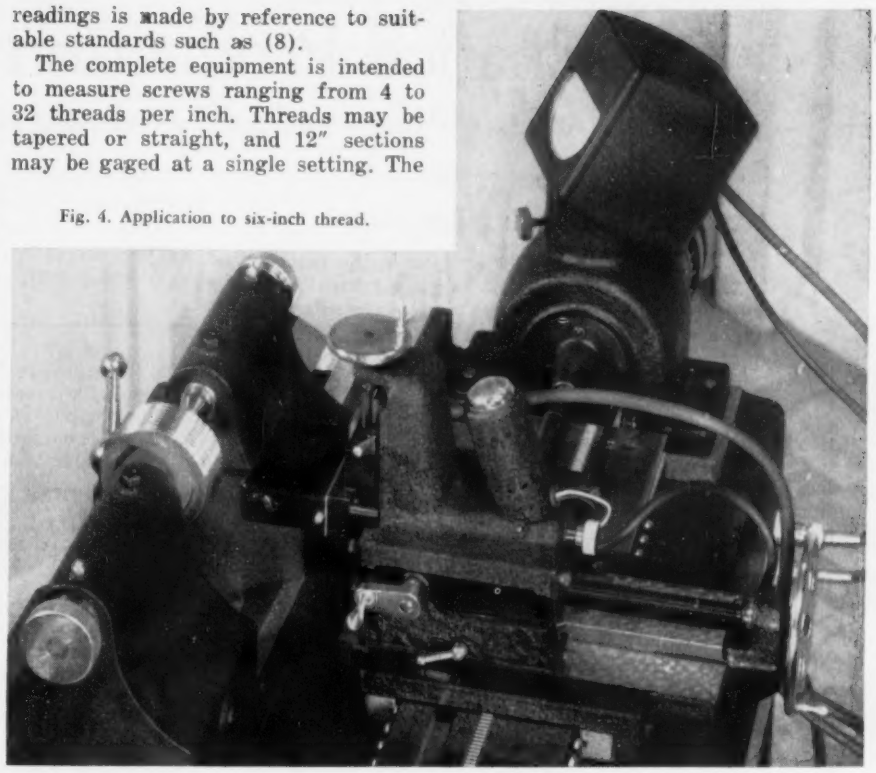
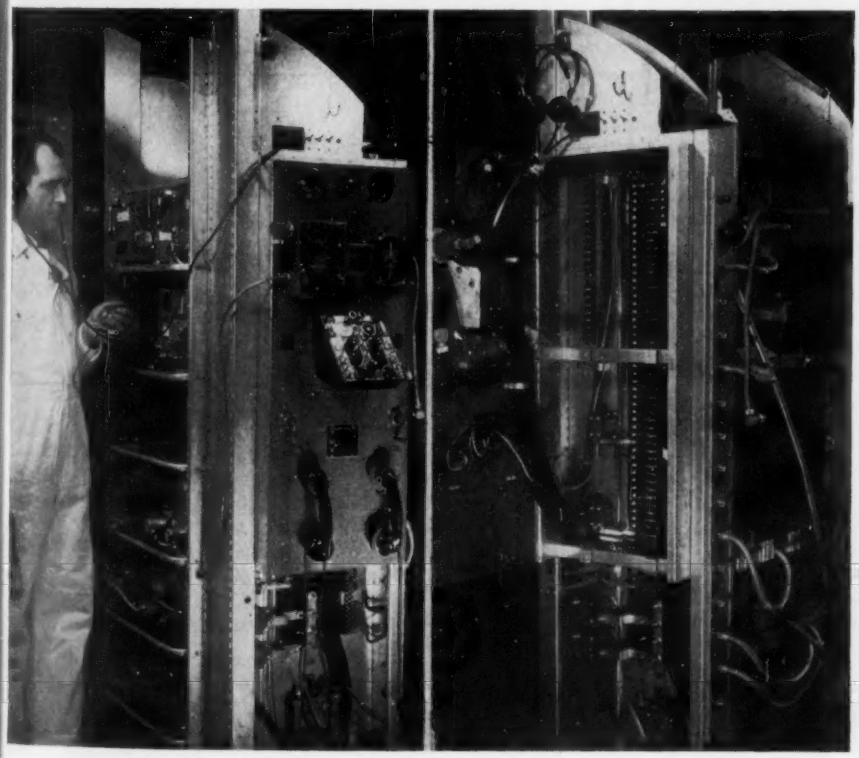


Fig. 4. Application to six-inch thread.

The usual model has an amplification of 2500, but other amplifications ranging from 250 to 10,000 are also obtainable by means of minor changes in the instruments.



Radio Rack Mock-up

THIS novel mock-up of a radio rack of the same type as used in United Air Lines Mainliners is employed for test purposes in the radio electric shop of United's central maintenance base at Cheyenne, Wyo. The mock-up carries all radio equipment installed on a Mainliner and is so wired that sending and receiving sets can be operated as in flight. The mock-up is used by radio engineers in making studies of possible changes without the necessity of holding an airplane out of service during such tests.

New Course at Brown Instrument Co. School

A NEW industrial instrument maintenance and repair course has been started by the Training School Division of The Brown Instrument Co., Philadelphia, Pa. Changes have been made in the general outline of the course, especially that having to do with instructions in the two types of potentiometers, mechanical and electronic. The two types are treated as separate subjects to make it easier for students to absorb the basic principles of each, and to meet the requirements of customers who send students for the specific purpose of receiving continuous-balance instrument instruction.

The new classes will extend to April 26. Schedule: Millivoltmeter type pyrometers, February 1 to 18; mechanical potentiometers, February 21 to March 8; continuous-balance (electronic) potentiometers, March 9 to 16; electrically-operated automatic controllers, March 17 to 23; flowmeters, March 24 to April 3; thermometers, pressure gages and hygrometers, April 4 to 11; air-operated automatic controllers, April 12 to 20; resistance thermometers and tachometers, April 21 to 26.

Ordnance Production Gaging

By Major R. A. BOWMAN, In Charge Gage Laboratory, Pittsburgh Ordnance District, U. S. Army

CHAPTER X

ACCURACY OF GAGE INSPECTION

CONSISTENT accuracy in inspections is the most important single responsibility of a gage laboratory. In a laboratory employing a large percentage of specialized personnel who are not necessarily familiar with all phases of manufacture and inspection, and consequently are not familiar with the errors which may arise in the manufacture of gages or the consequences of these discrepancies, the problem of accuracy is greatly increased.

The four most usual reasons for inaccuracies in inspection are:

1. Inaccurate Standards
2. Burrs and Scratches
3. Dust and Dirt
4. Temperature

These factors should be investigated first when doubt arises as to the accuracy of an inspection. The first (inaccurate standards) is a responsibility of management and may be solved by proper surveillance of equipment. The other three are a responsibility of the worker and must be eliminated through proper training of personnel.

Standards. A standard is defined as "Of a high or recognized order of excellence." The standards in the gage laboratory are accepted without question by the personnel who use them, and so those standards must be unquestionably accurate.

In the gage laboratory, the most usual errors due to improper standards arise because of wear in gage blocks, wires, rolls, etc., and when it is realized that a gage block will wear approximately one millionth every thirty times it is wrung, it will be seen that some adequate means of surveillance of gage laboratory equipment is required.

In any plant, the measurement control should stem from one source such as one set of gage blocks. This standard of measurement must be transmitted to the final product. In some plants, the gages alone will be the standard; in other plants, one set of gage blocks will be used to set all the gages. In a large organization having a gage laboratory of several people, it may be necessary to have several sets of blocks in which case one should be used merely to check for discrepancies in all the other sets. Ultimately, all standards for measurement in the United States stem to the National Bureau of Standards where measurement is made with light rays.

A definite system should be set up so that all gage blocks, wires, rolls, etc. are inspected periodically for size in order to maintain measurement standards.

Burrs and scratches. When metal is scratched, the metal which had previously been in the depression does not, of course, vanish. It is heaved up along the sides leaving, in effect, a valley with a mountain on each side. Naturally, the remaining surface is not a plane and other surfaces placed upon it will probably be scratched and in addition will rest on the top of the burr rather than the plane where they were originally intended to rest. A scratch in laboratory equipment may conceivably raise a burr several thousandths in height. *When a surface is scratched, it should never be re-used for measurement purposes until the resulting burr has been stoned off.* Surface plates, vee blocks, angle plates, parallels, and the like are most susceptible.

Dust and dirt. Whenever any surface is oiled or greased, it will collect dirt. Particles of dirt are normally measureable, and therefore, a piece of dirt between a surface plate and a surface gage may scratch both if it is hard enough and will certainly affect a reading taken with the surface gage. Equipment should always be wiped clean before it is used. Dirt *always* collects on flush pin gages, indicators, and wherever oil is used.

Temperature. Examination of the formula for temperature coefficient of expansion will show that the expansion is a function of temperature differential, length, and the physical properties of the material. It is also obvious from the formula that, if length and temperature are the same, the difference in length of two units due to a change in the temperature is entirely dependent upon their difference in coefficient of expansion. The coefficient of expansion of all iron and steel does not vary over four tenths of one millionth from 0.0000067 to 0.0000071 and consequently, in any inspection setup, if a steel gage is being checked with steel gage blocks and both are at the same temperature, they are obviously the same length, their difference in length will be less than 0.0000004 times their deviation in temperature from 68°F.

If, then, the gages, measuring equipment, and standards are all brought to the same temperature, the error due to temperature will be negligible for most work. A dividing line between cases where temperature differential is negligible and cases where it is not negligible is sometimes set as follows: When it is desired to measure more accurately than 0.0001 regardless of size or 0.00005 per inch of length, the inspection is made at standard temperature, 68°F.

Inaccuracies due to temperature are most usually found where thin sections of metal are involved; i.e., thread checking wires, rolls, "thin" gage blocks, etc. where, due to the physical shape, body temperatures may be picked up rapidly. If the shape is such that body temperatures will be picked up rapidly, they will, of course, be dissipated just as rapidly so that, ordinarily, if the hands are used to place the wires in the threads in a supermicrometer, a few minutes will suffice to allow the wires and plug to come to the same temperature. If possible, a large flat surface of steel such as a surface plate should be close to each inspector, and when wires, rolls, gage blocks, etc., are handled, they may be placed upon the iron into which they will dissipate heat above room temperature quite rapidly. If these procedures are followed conscientiously, little difficulty should be experienced due to temperature.

This unique serial is based on the remarkably successful course of lectures by Major Bowman (then Lieutenant) to us Reserve Officers, in which he combined the fruits of his civilian experience as Gage Supervisor and of his Ordnance training. —MFB

CHAPTERS PREVIOUSLY PUBLISHED. I. Interchangeability—Sept. '41 and May '42; II. Inside Dimension Gaging—July '42; III. Outside Dimension Gaging—Aug. '42; IV. Offset Dimension Gaging—Sept. '42; V. Position and Alignment Gaging—Oct. '42; VII. Profile Determinations—Dec. '42; VIII. Thread Gaging—Feb. '43; VI. Taper and Angle Determinations—Mar. '43; IX. Gage Laboratory Equipment—first instalment April '43, second instalment June '43, third instalment Nov. '43.

Re: Gage Blocks Wear Through Wringing

. . . In Chapter IX of "Ordnance Production Gaging" by Capt. Bowman, under "Special Care of Gage Blocks" (April 1943 *Instruments*, page 195) we note the statement: "Experience has shown that 240 wringings result in a wear of eight millionths of an inch."

We are not questioning this statement but just want to pass along the information that the writer had a communication from one of the men in our Production Gage Department stating that two Johansson Gage Blocks have been wrung together over a thousand times and that they were unable to determine any wear.

O. E. GREEN
Johansson Div., Ford Motor Co.

A Simple "Pocket" Instrument for Measuring Sag in Telephone Lines

By GEORGE M. BYRAM, Assoc. Meteorologist, Appalachian Forest Experiment Station, Asheville, N. C.

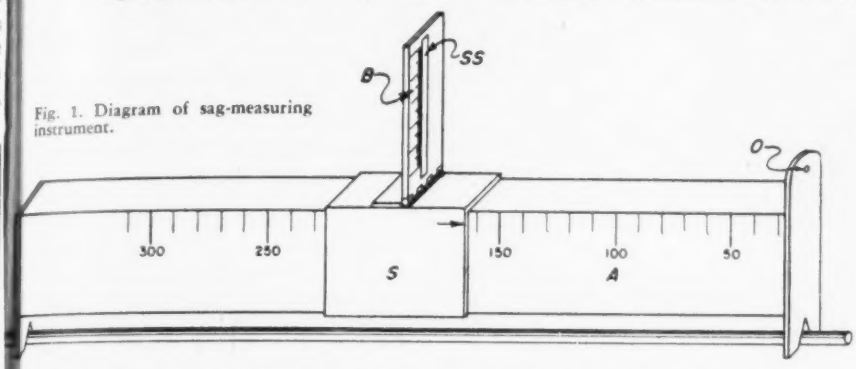


Fig. 1. Diagram of sag-measuring instrument.

IN regions where there is a large difference between winter and summer temperatures, telephone lines erected during the summer months must be given sufficient sag to prevent them from breaking during the following winter when low temperatures cause the wires to contract. If too much sag is left in a line, wind makes the wires swing, straining the supports and insulators. Excessive sag allows metallic circuits to become shorted by the wires swinging together at transposition points. For any expected temperature range, tables are available giving the proper amount of sag which the wire in a span of any given length should have.

A simple instrument has been devised with which a lineman may measure sag so that the required slack in the line can be introduced when the line is constructed. The body of the instrument is a hardwood strip (Fig. 1) on the ends of which are fastened two brass strips with v-notched bottoms. To measure sag, the instrument is placed near one of the span supports so that the telephone wire fits into the notches of these brass strips. The sliding section S is moved until the arrow point touches the division on the horizontal scale A corresponding to the length of the span in feet. The observer then looks through the pinhole O and through the vertical slit SS, sighting on the insulator on the opposite pole. The sag in inches is read from the vertical scale B at the point where that insulator appears in the slit. The upright scale is hinged so that it may be lowered when not in use.

The theory of the instrument is as follows: A telephone wire hangs so that it forms a curve whose equation is (approximately) the parabola

$$y = ax^2 \qquad (1)$$

where y is the sag and x is one-half the length of the span. Taking the first derivative of y with respect to x gives

$$dy/dx = 2ax \qquad (2)$$

Eliminating the constant a between equations (1) and (2) gives

$$y = (x/2)\ (dy/dx) \qquad (3)$$

The instrument measures dy/dx and, since x (½ of the span length) is known, then y is easily determined. The horizontal scale on the instrument represents dx and the vertical scale dy. The proper units are determined by writing equation (3) in the form

$$dy = (2dx/x)\ y \qquad (4)$$

If dx is 1′ when the span is 200′ (i.e. when $x = 100'$) then

$$dy = \tfrac{1}{50}\ y \qquad (5)$$

so if y is to be in inches then dy should be in fiftieths of an inch (each $\frac{1}{50}$″ representing 1″ of sag in the wire). The number 200 (representing a span length of 200′) is placed 1′ from the zero end of the horizontal scale; the rest of the span-length scale is then divided into any desired linear intervals of span length such as 10′ or 25′. It will be noticed that each foot of span is equal to $\frac{3}{50}$″ on this scale, hence is 3 times the length of the unit representing 1″ of sag on the vertical scale. Different units may be used for different sizes of the instrument, but if the sag is to be measured in inches and the span in feet, the horizontal and vertical units must always bear the ratio of 3 to 1.

A telephone wire actually hangs so that its curve is a catenary, the equation of which is the hyperbolic cosine $y = c \cosh (x/c)$. A chain or cable loaded uniformly per unit length will form a catenary but if loaded uniformly per unit horizontal distance will form a parabola. Since the two curves are almost identical when the sag is small and are similar even when the sag is fairly large, a negligible error is made in assuming that a telephone wire hangs in a parabolic curve.

An accurate reading cannot be obtained if the tension in the wire is not great enough to straighten out kinks and bends in that part of the wire on and near which the instrument is resting. However, if the lineman sights along the wire, he can detect those bends near the point of support and straighten them out before taking a measurement. There also will be a small error in measurements made on steep slopes if the sag is more than 2% of the span length. The error is small if the measurement is made from the higher pole to the lower pole, but if the direction is reversed the error of measurement may be as great as 15% on a 100% slope. For instance, if the actual sag is 14″, the instrument may show 16″ of sag if the measurement is made from the lower pole. This error, however, decreases rapidly for less steep slopes and with smaller sag-span ratios. The instrument cannot be used satisfactorily to measure sag in wires near the ends of long cross-arms, too distant from the pole to permit easy sighting with the device.

"Ship-mast" Type Testing Machine

IT is well-known that instruments for the Armed Forces are tested under extreme conditions such as high or low temperatures, low barometric pressures, salt spray, vibrations, etc. But here is what probably is the first testing machine of its kind — a machine for testing devices designed to operate at the top of a ship's mast. It is a rocking tower which simulates pitch and roll of a ship, developed by J. G. Ritter, War Products Engineer at Westinghouse Electric & Mfg. Co., East Springfield, Mass. Built to oscillate through an arc of 45° from the vertical, or 90° altogether, the tower is 50 feet high from the center of oscillation. Its counterweight contains 2 tons of steel, although the tower itself weighs only 600 lbs. In appearance, it resembles a radio mast. A 35-horsepower motor, in connection with a Westinghouse-Nuttall oil well reduction gear unit, is used to rock the tower at periods of oscillation varying from four and one-half seconds to ten seconds. At the fastest rate, the velocity at the midpoint of the swing reaches 45 miles per hour. At this point, however, the acceleration is zero. It is the reversal at the end of each half-cycle which puts the greatest stress on the tower. The base which supports the whole thing is made of 12″ I-beams, weighing 30 lbs. per foot.

ELECTRON TUBES—Their Principles and Their Instrumentation Applications

By ANDREW W. KRAMER, Managing Editor, Power Plant Engineering, Chicago, Ill.

CHAPTER X
DEVELOPMENT OF THE ELECTRON-TUBE OSCILLATOR

Having described the effect of the presence of gas in a thermionic tube, we will now return to the high-vacuum tube and continue our discussion of its properties. To present this discussion properly it is desirable and, incidentally, interesting to consider briefly a little more of the history of the electron tube.

As has been explained, the electron tube had its birth and passed its childhood in the radio field—in the field of wireless telegraphy as it was known then. The term "radio" did not come into general use until around 1920; before that, people talked about "wireless."

In the early days of wireless communication—the period of the spark transmitter—the greatest need was a sensitive, reliable detector. The function of the detector was that of rectifying the extremely weak high-frequency alternating currents induced in the receiving antenna by the electromagnetic waves.

A number of detectors had been developed. Marconi used a tiny glass tube of iron filings invented by Branly. This, the "coherer" as it was called, was not a rectifier but it served to detect the high-frequency currents in a different way. When connected in series with a few dry cells and an electric bell or buzzer, such a tube of iron (usually a mixture of iron and nickel) filings normally presents a high resistance to the flow of electricity and little or no current exists in the circuit. The instant high-frequency currents are passed through such a tube some change occurs, the tiny particles of iron come together (cohere), and the resistance of the tube is instantly lowered, permitting current from the battery to flow and thus operate the buzzer. Once the high resistance of the tube has been broken down in this way the condition remains even after the high-frequency current has ceased to flow but the initial high resistance can be restored by shaking or tapping the tube. It was the practice therefore to arrange the buzzer clapper so that it would strike the tube as shown in Fig. 67. With this arrangement the coherer was always in a sensitive condition and the buzzer would continue to operate as long as the high-frequency current persisted.

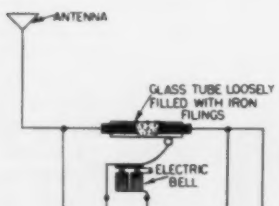


Fig. 67. The "coherer" which Marconi first used as a detector was not a rectifier as were most later type detectors. High-frequency currents from the antenna broke down the tube's high initial resistance and closed the circuit through a bell or buzzer. Movement of the bell clapper, however, immediately restored the tube's high resistance.

The coherer of course has nothing to do with electron tubes but it forms part of the history of detectors and it is therefore of interest here.

Other detectors used were purely rectifiers. A high-frequency train of waves such as that shown in Fig. 68 for example could not actuate a telephone receiver or an ordinary electromagnetic instrument. In the first place the frequency (over 100,000 cycles per sec.) was so high that no mechanically moving diaphragm could respond to it and, secondly, the impedance of ordinary coil windings such as those of telephone receivers is enormously high to such frequencies.

(Impedance, $Z = \sqrt{R^2 + X^2}$, is a function of the frequency. In this expression X^2 represents the total reactance, that is, it is the combined inductive ($2\pi fL$) and capacitive ($\frac{1}{2\pi fC}$) reactance. Each of these latter expressions, it will be noted, contains the term f, frequency. Hence the impedance Z of any circuit is dependent upon the frequency of the current.)

By introducing a half-wave rectifier into a high-frequency circuit, a high-frequency wave train such as that shown in Fig. 68 will have the negative portion suppressed, and a direct current such as shown in Fig. 69 will flow. This current will actuate a telephone receiver.

Various types of rectifiers were used in the early wireless receivers. Some of these were electrolytic cells, others used the unilateral conductivity of certain natural crystals, silicon, galena, etc.

John Ambrose Fleming in England was the first to use a thermionic tube for this purpose. His tube was a simple diode. While this diode, known as the Fleming valve, was not noticeably more sensitive than other forms of detectors then in use, it had the distinct advantage of being much more stable in its operation and far less critical in its adjustment.

The next step was the introduction of a third element into the tube by DeForest as already explained. This was a notable advance, for the three-element tube, as has been shown, is not only a rectifier but also an amplifier. It not only rectified the weak high-frequency currents induced in the receiving antenna but it also amplified them. Therefore the DeForest "Audion," as it was called, was a much more sensitive detector than any theretofore developed. It was immediately adopted by many experimenters and its advantages over the older detectors were numerous. A typical circuit is shown in Fig. 70. The incoming signal currents induced in the antenna are transferred to the receiver circuit by a coupling transformer T which is associated with a resonant circuit L C by means of which the circuit is "tuned" to the frequency of the incoming signals. The voltage developed across this resonant circuit is impressed across the grid cathode elements of the tube and combined rectification and amplification takes place in the manner described in earlier chapters.

Fig. 68. High-frequency wave-train in the antenna circuit produced by early spark transmitters.

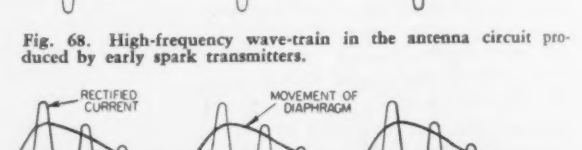


Fig. 69. Effect of rectifying high-frequency oscillation groups such as shown in Fig. 68. The frequency of the high-frequency pulses is, of course, too high for the diaphragm of a telephone receiver to follow. The diaphragm therefore follows the average effect, shown by the heavy line.

It is not our purpose to enter into a detailed study of radio, but these matters lead up to the next fundamental property of the electron tube and they are of more than mere historical interest.

About 1912 we find a number of investigators using the DeForest Audion. As a detector it was a marvel but occasionally the circuits in which it was used had a tendency to "howl" or whistle. These squeals and whistles were re-

garded with annoyance at the time, even by DeForest himself, but they were important and subsequently these squeals were introduced in famous court proceedings regarding patent rights involving millions of dollars. Among other investigators was a young student at Columbia University by the name of Armstrong doing post-graduate work in radio. One afternoon, so the story is told, he had a receiving circuit set up in the laboratory and was listening to the familiar signals known to every radio man, amateur or commercial, of station WCC at South Wellfleet, Massachusetts. These signals were noted for their constancy and their unmistakable characteristic ring. On this particular afternoon they were steady as usual but as young Armstrong made some changes in the adjustment of the circuit, the signals suddenly began to increase in intensity to a degree far beyond anything he had ever heard or hoped to hear. Amazed, he carried the adjustment further and still the intensity of the signals increased and then with startling suddenness they became deafening and changed their character entirely. Instead of the clear, old familiar ring, they become mushy—hissing. Something remarkable had happened and Armstrong began to study his

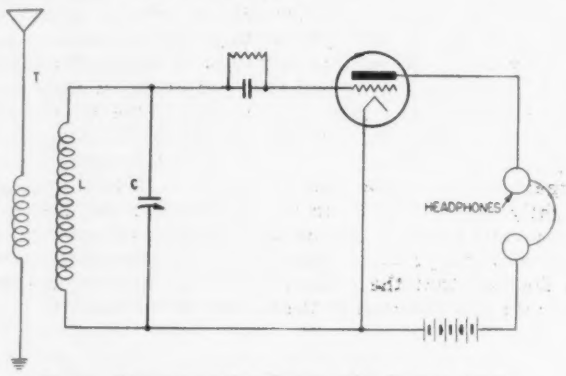


Fig. 70. Non-regenerative electron tube detector circuit.

circuit and labored at it all that summer. It was many weeks before he understood all that had happened in the circuit that afternoon but when he did, he was able to announce his famous principle of "regeneration." And for years the Armstrong regenerative circuit was used throughout the world.

Now what had happened? Simply this: Since the three-electrode tube is an amplifier, its output is greater than its input. This being the case, it is possible to take a portion of the output and feed it back into the input. Somehow this action had occurred in Armstrong's circuit. Indeed, it had occurred in various other circuits, even before Armstrong's, and it was no doubt responsible for the squeals and erratic behavior of some of the circuits; but Armstrong was the first to recognize the phenomenon for what it was. This feed-back action can be accomplished in various ways, by magnetic coupling, by electrostatic coupling or by combinations of electrostatic and magnetic means.

Consider the circuit in Fig. 71. This is practically the same circuit as that shown in Fig. 70, except that an inductance coil L_1 has been introduced into the plate circuit and arranged so that its magnetic field intersects the input coil L. Normally, alternating voltage from the antenna is fed into coil L. This voltage is amplified by the tube and appears in greater amplitude in the plate circuit. In Fig. 71, however, by means of the coil L_1 some of this amplified alternating voltage is fed back into the grid circuit, so that even if the external exciting source (the antenna) is removed, and if enough energy is fed back, alternating voltage will still appear across both the grid and the plate circuits. By varying the degree of coupling between the two coils, L and L_1, more or less energy can be fed from the output back into the input. If enough energy is thus fed back, the circuit will continue to sustain electrical oscillations as long as direct potential is available from the plate battery. Only enough energy need be supplied by the battery to make up for the losses in the circuit.

Now, what happened to young Armstrong's circuit that afternoon at Columbia University becomes evident: In adjusting the circuit constants he had effected a coupling between the output and input sides of the circuit and energy from the output circuit was added to that in the input circuit. This was again amplified and again fed back to the input side, and so on, the cycle was repeated, the signals growing stronger with each successive cycle. All this, of course, occurred in far less time than is required to tell about it. This was the now-familiar phenomenon of regeneration.

As long as the coupling between the input and output sides of the circuit was such that only a small amount of energy was fed back, the only effect was to increase the strength of the current in the circuit. The effect of the "feed-back" was only to neutralize part of the normal losses in the circuit.

Suppose, however, that the amplification is such that the amount of energy fed back is sufficient to make up for all the losses and still have some power left; then, this power will appear as self-oscillations.

This is what happened in Armstrong's circuit. As the coupling was gradually increased there came a time when

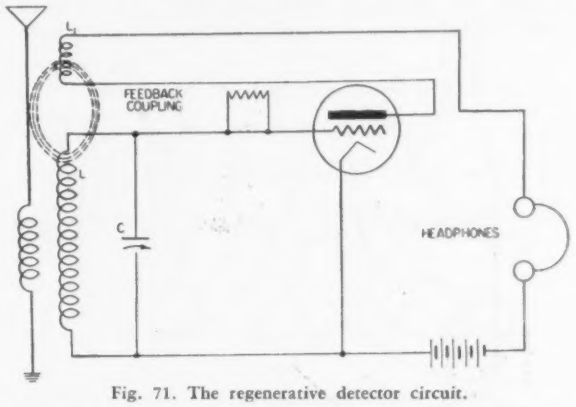


Fig. 71. The regenerative detector circuit.

the feed-back was sufficient to neutralize the losses in the circuit and the circuit began to "oscillate," that is, it became a generator of high-frequency oscillations.

The signals from the antenna, however, were still being applied to the input side of the circuit. The frequency of these signal currents was not exactly the same as the frequency of the oscillations generated in the circuit, since the latter frequency was determined by the circuit constants. Hence, these two frequencies interfered with each other and it was this interference or mixing of frequencies that was responsible for the abrupt change in the character of the sound heard in the earphones.

So much for the historical side. We have included it here not only because of its inherent interest but to show that the ability of electron-tube circuits to "oscillate" is a consequence of the tubes' ability to amplify. Armstrong's original purpose was to amplify the signals. The fact that the circuit broke into oscillation was more or less accidental but it serves to show how easily such circuits can be made to oscillate. While the principle of oscillation is of tremendous importance in electron-tube circuits—for it forms the very basis of modern radio-communication systems—at the same time it is troublesome. Anybody who indulged in the almost universal indoor sport of kitchen-sink radio construction in the early twenties will recall the heart-breaking effects of oscillation. For the howls and squeals and wheezes of those home-made radio sets were all manifestations of unwanted oscillations and despite all elaborate efforts to prevent them, they persisted. In the years since, much has been learned about electron tubes and tube circuits and today the tube engineers and circuit designers know how to prevent oscillations when they are not wanted and also how to produce them efficiently where they are wanted. Indeed, as an efficient generator of high-frequency electric oscillations, the electron tube has displaced all other methods. Its range of frequency is enormous, extending from those of less than a cycle per second to those as high as a billion or more cycles per second.

CHAPTER XI

TYPES OF OSCILLATING CIRCUITS

The ability of the electron tube to generate electrical oscillations from direct current is an important and valuable function since it provides a means of generating alternating currents of any frequency with purely stationary apparatus. Its most important application in this respect is in the radio field where it is used to produce the high-frequency currents (from 20,000 to 500,000,000 or more cycles per second) necessary for efficient electromagnetic radiation. Tubes can, however, just as easily produce frequencies of much lower orders for industrial purposes, and an increasing number of applications are being made in this field today.

Since this mechanism of oscillation is so important, it is desirable to consider it in somewhat greater detail.

As already explained, an electron-tube oscillator is simply a self-excited amplifier. An impulse delivered to the input side of the circuit is amplified; part of this amplified impulse in the output side of the circuit is then fed back to the input side and the process repeated. The system supplies its own input.

Suppose, for example, that 1 milliwatt (0.001 watt) is required to excite the grid of a triode amplifier and that

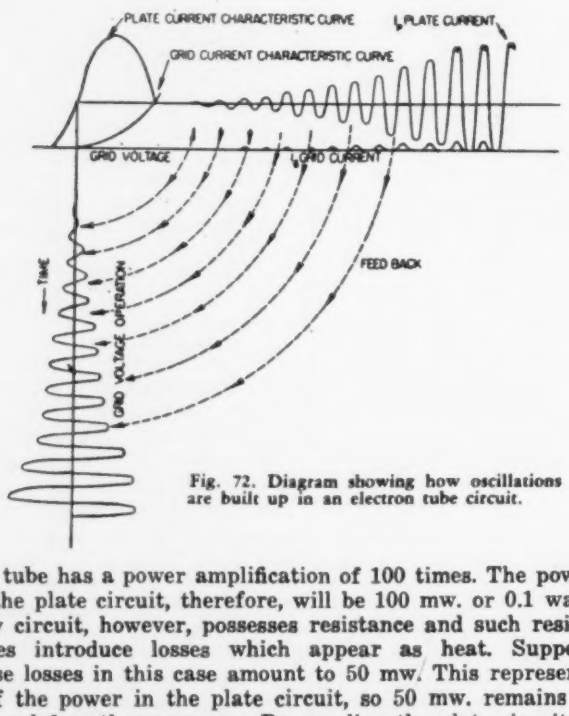


Fig. 72. Diagram showing how oscillations are built up in an electron tube circuit.

the tube has a power amplification of 100 times. The power in the plate circuit, therefore, will be 100 mw. or 0.1 watt. Any circuit, however, possesses resistance and such resistances introduce losses which appear as heat. Suppose these losses in this case amount to 50 mw. This represents half the power in the plate circuit, so 50 mw. remains to be used for other purposes. By coupling the plate circuit to the grid circuit some of the output voltage excites the grid and if this is in the proper phase to add to the original exciting voltage, this new additional voltage will be amplified and some of it will again be returned to the grid circuit. This current which is fed back from the plate circuit has the effect of neutralizing some of the resistance of the circuit.

Now, of course, we know that resistance is a property of the circuit and, as such, it cannot be neutralized. If resistance could be neutralized, however, the effect would be, with a given voltage, to increase the current.

This is exactly what occurs in the oscillator circuit. The feed-back has the effect of increasing the current; therefore, we can regard it as neutralizing the resistance. As the coupling is increased and more energy is returned to the grid circuit, there finally comes a time when the virtual resistance is zero—all losses being wiped out by the output power. From that time on the circuit continues to "oscillate." This is no violation of the principle of the conservation of energy—we are not "getting something for nothing" —the extra power is derived from the batteries in the plate circuit.

This process of building up oscillations is practically instantaneous in ordinary circuits. It may take but a few cycles to arrive at the oscillating condition and since the frequency usually is very high—millions of cycles—the actual time of building up is extremely small. Theoretically, oscillations cannot start unless some initial disturbance starts the first cycle in the grid circuit, but in any practical circuit there are plenty of disturbances. The mere snapping on of the plate voltage or the shaking of a tube is sufficient to initiate the action. The slightest voltage change in the grid circuit produces a corresponding but amplified change in the plate circuit. This change continues in the same direction as far as the characteristics of the tube and the constants of the circuit will permit. When the current is increasing, the change continues until the plate current reaches its saturation value. In the opposite direction, or toward less plate current, the change continues until the anode current reaches zero. As the limit is reached in each direction successively, the trend reverses. Thus, the current oscillates about the nominal d-c. value of anode current to which the tube is biased.

The mechanism of building up oscillations is illustrated graphically in Fig. 72. In this diagram the plate and grid current characteristics of the tube are shown in the upper left hand corner. The grid voltage oscillations are shown directly below. By projecting values of this grid voltage to the plate characteristic and then projecting at right angles in the manner described in Chapter IV, the corresponding plate current variations are plotted horizontally at the right. A small impulse in the grid circuit produces a similar larger impulse in the plate circuit. This in turn produces a slightly larger impulse in the grid circuit and the oscillations build up until an increase in grid voltage no longer increases the pulsating current in the plate circuit owing to the fact that the plate current can neither pass below the zero line (because of the unilateral conductivity charac-

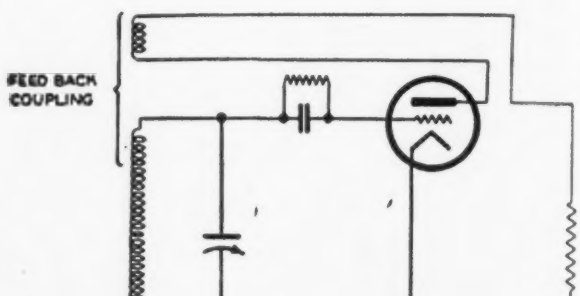


Fig. 73. An inductively coupled oscillating circuit. This is the same circuit that was shown in Fig. 71 except that it is not coupled to an antenna and that the headphones are replaced by a simple resistor.

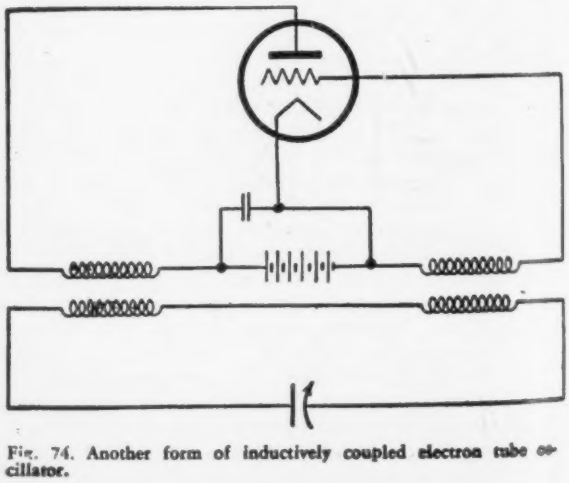


Fig. 74. Another form of inductively coupled electron tube oscillator.

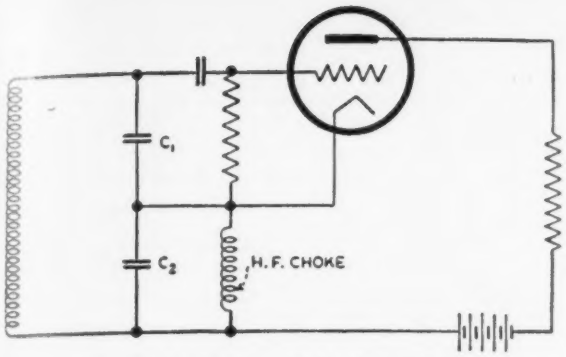


Fig. 75. A capacity coupled oscillator circuit.

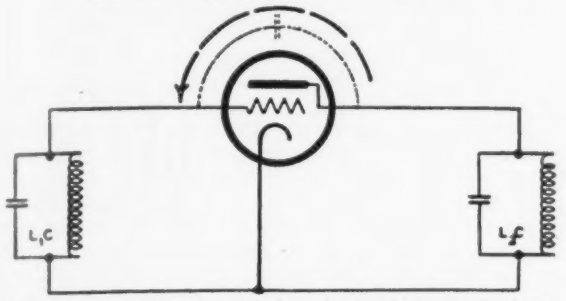


Fig. 76. The tuned-grid tuned-plate circuit which uses the inter-electrode capacity of the tube to effect coupling between input and output circuits.

teristic of the tube) nor increase above the saturation value. The oscillations are then maintained at constant amplitude.

It is possible to build circuits in which oscillations build up slowly but as a rule circuits are too willing to oscillate and elaborate precautions often are necessary to keep amplifiers from "winding up" and breaking into continuous oscillation.

This more or less "natural" tendency of electron tube amplifiers to oscillate may not be apparent from the circuit we have considered, Fig. 73. For unless the feed-back arrangement is purposely introduced, how is the energy from the plate circuit transferred back to the grid circuit?

This is a logical question. Its answer lies in the fact that the feed-back coupling may be effected in a number of ways. The inductive method in Fig. 73 is only one of a number of arrangements. The feed-back can be accomplished just as easily by capacitive coupling, i.e., by the use of a capacitor. Various inductive methods are possible. In Fig. 74, for example, is an arrangement slightly different from that in Fig. 73 although in principle it is exactly the same. Here the coupling is effected through a separate circuit which is coupled inductively to both the plate and grid circuits of the tube. In Fig. 75 the coupling is effected by means of the voltage developed across a small capacitor C_2. The power is extracted by the grid circuit by the voltage across C_1. With this type of circuit the direct-current power furnished by the plate battery is connected in series with a high-frequency choke coil.

If Fig. 75 is examined closely, it will be noted that both capacitors C_1 and C_2 through which the feed-back coupling is effected are in parallel with the tube elements. The tube elements themselves, however, constitute the elements of a small capacitor and it is easily conceivable that if the capacitance formed by the grid and plate electrode is great enough, the coupling capacitors could be dispensed with entirely. This actually is the case in the Armstrong tuned-grid-tuned-plate circuit shown in Fig. 76. This is one of the circuits invented by E. H. Armstrong who first studied the feed-back action in electron-tube circuits and who gave a qualitative explanation of it. In this circuit, as indicated by the arrow, the energy is fed back through the capacity effect of the tube itself. When the natural frequencies of both resonant circuits LC_1 and LC_2 are adjusted to the same value, the maximum energy transfer takes place because with those conditions the voltages developed across these circuits will reach their highest values.

Now it becomes evident why it is so difficult to prevent oscillations from building up even in circuits that are not specifically designed for this purpose. For if the tube itself can act as the coupling device it naturally becomes difficult to avoid the condition. This difficulty increases as the frequencies involved become higher because at high frequencies the capacity effect of the tube elements becomes increasingly greater. (The capacity reactance is equal to $1/2\pi fC$ in which C is the capacitance of the capacitor in farads and f is the frequency in cycles per second.)

At the high frequencies used in radio, the capacity effect of the tube elements becomes so marked that special methods for neutralizing tube capacitances become necessary. These will be described in later chapters.

The essential principle in all of these arrangements, however, is the same whether the energy is fed back through the tube by capacitor action or through separate capacitors or coils. This principle may be made clearer, perhaps, by means of the diagram shown in Fig. 77. Here the flow of power can be traced. Coming originally from the B battery or other source of direct-current power in the plate circuit, part of it is absorbed by the load and the rest is dissipated in the tube itself. Once started, the energy travels around the (vicious) electric circle shown and the oscillations build up until the limit of the tube's capacity is reached.

In any case, the load circuit usually contains an inductance and capacitance which determine the frequency of the generated oscillations. It is by suitably proportioning these constants (inductance and capacitance) that the frequency of the oscillations is determined and, as already pointed out, by this means frequencies from those of less than a cycle per second to those of millions per second can be generated. In radio work, the function of the oscillator is primarily to supply currents of frequencies of millions of cycles per second to the transmitting antenna.

As pointed out, however, the oscillator can be used to supply high- or low-frequency alternating current for any

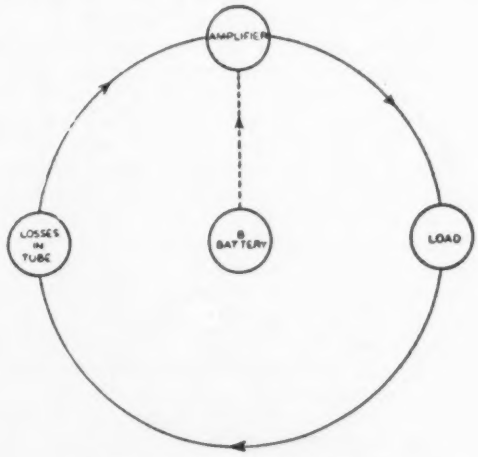


Fig. 77. The oscillating cycle.

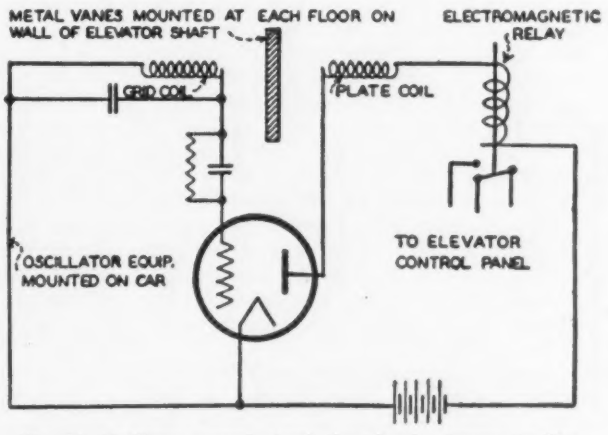

METAL VANES MOUNTED AT EACH FLOOR ON WALL OF ELEVATOR SHAFT
ELECTROMAGNETIC RELAY
GRID COIL
PLATE COIL
OSCILLATOR EQUIP. MOUNTED ON CAR
TO ELEVATOR CONTROL PANEL

Fig. 78. Oscillator control circuit for electric elevator leveling control.

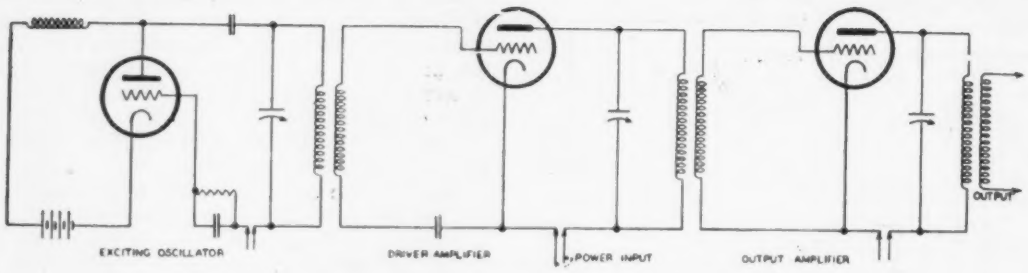


Fig. 79. Oscillator-amplifier arrangement for producing oscillations of great magnitude.

other purpose. In industry it is used for many purposes, for producing extremely localized heat in plastic molding operations, in the drying of plywood, for case hardening steel parts, in welding operations, etc. The number of such applications is increasing daily. The oscillating tube is also used in many automatic-control instrument applications.

An excellent example of the oscillator tube as an automatic-control device is in a system of leveling control for electric elevators. In this system, shown in Fig. 78, the oscillating circuit with the plate and grid coils is mounted on the elevator car. On the walls of the elevator shaft, metal plates or vanes are mounted at each floor so that as the elevator passes the floor one of these plates passes between the plate and grid coils. Normally the circuit is in an oscillating condition. As the elevator passes a floor, however, the metal plate comes between the coils and the feed-back action is stopped, since the metal plate acts as an effective shield against the electromagnetic transfer of energy. As a consequence the plate current falls, which actuates the relay and this sets in motion the equipment which brings the elevator to the exact position required with respect to the floor.

Any electron-tube oscillator may be used to excite other amplifiers. When high-power output is required, it is usual to produce oscillations by means of a small tube and of relatively low power. This oscillator is then coupled to succeeding amplifiers consisting of larger tubes which amplify the weak oscillations produced by the oscillator. By arranging a number of amplifying stages in "cascade" in this manner, it is possible to produce high-frequency currents of hundreds or even thousands of kilowatts. This is the method used in all broadcast and high-power radio transmitting stations. Similar circuits are used in industrial applications. A simplified diagram of such an arrangement is shown in Fig. 79. At the left is shown a simple oscillator of the type we have considered. This is magnetically coupled to an intermediate amplifier which amplifies the weak oscillations produced by the oscillator. This intermediate amplifier in turn is coupled to a final output amplifier in which the oscillations are again amplified and delivered to an output circuit.

CHAPTER XII
NEUTRALIZING ELECTRON-TUBE AMPLIFIERS

So far, tubes with only two and three elements have been considered. Other elements may be added, however, to enable tubes to fulfill certain specialized functions and applications. Also, two or more sets of elements may be combined in one envelope so that a single tube may be used to perform two or three separate functions. An extremely simple example of the latter principle is the double-anode rectifier shown in Fig. 80, which with a single tube permits full-wave rectification as explained in Chapter III.

Tubes with more than three elements generally are called multi-element tubes; specifically, tubes with four elements are called tetrodes, those with five elements, pentodes. Many element combinations and structures become possible as the number of electrodes is increased, but such tubes, thus far, have had little application outside of the communication field. In a number of cases, additional elements are provided to control and direct the flow of electrons in certain ways.

Of the several possible four-element arrangements, one of the most important and one that has been in wide general use for many years is that used in the screen-grid tube.

To explain the nature of the screen-grid tube it is necessary to refer again to the ability of a triode to generate sustained oscillations through the return of energy from the plate to the grid by virtue of the electrostatic capacity existing between the plate and grid, in a circuit such as shown in Fig. 81. This circuit is an oscillating circuit, but it should be noted that it is fundamentally the same circuit that would be used as an amplifier, that is, it is a circuit which may be designed to amplify but not oscillate at radio frequencies. For effective amplification, the input and output circuits must be *tuned* to the same frequency.

At low frequencies, no difficulties are encountered with this type of amplifying circuit, but at high frequencies the grid-plate capacity effect of the triode becomes so large that it serves as an effective coupling between the two sides of the circuit. As a consequence, so much energy is returned

Fig. 80. The double diode. By means of a single cathode and two plates all mounted within a single bulb, the functions of two tubes are combined in one.

to the grid circuit that it is impossible to prevent the circuit from setting up sustained oscillations. Because of this, a triode cannot be used as an amplifier at high frequencies unless special circuits are employed. When the amplifier is designed to operate over a relatively small frequency range, such special circuits are satisfactory, but where a considerable frequency range is involved they possess certain shortcomings.

It is with respect to this phase of amplifier operation that the screen-grid tube has advantages. The screen-grid tube is nothing more than a triode with an additional grid introduced between the control grid and the plate. This second grid forms an electrostatic shield which reduces or neutralizes the grid-plate capacitance of the tube and thus prevents the return of energy to the grid circuit; hence it prevents oscillation. The shield-grid tube also has other advantages as will be explained.

Before the details of screen-grid tube operation are considered, however, it will be of interest to discuss briefly the special circuits mentioned above. The function of these circuits is to some extent like that of the screen grid, i.e., to neutralize the capacitance of the tube. And here again, as in the case of resistance, when we speak of neutralizing the capacitance we mean neutralizing the capacity effect. The process of neutralization really involves the taking of some of the radio frequency voltage from the output or input circuit of the amplifier and introducing it into the other circuit in such a way that it effectively "bucks" the voltage operating through the capacity of the tube, thus rendering it impossible for the tube to supply its own excitation. *For complete neutralization, it is necessary, therefore, that the neutralizing voltage be opposite in phase to the voltage*

through the grid plate capacitance of the tube and equal to it in value.

There are a number of ways in which this neutralization can be effected. All of them involve some sort of electric network or bridge circuit which transfers energy in a direction opposite to that through the grid-plate capacity of the tube. The out-of-phase voltage required in the neutralizing process can be obtained quite readily by using a balanced resonant circuit in either grid or plate and taking the neutralizing voltage from the end of the tank* opposite to that to which the grid or plate is connected. Such an arrangement is shown in Fig. 82. The lower end of the tank coil, it will be noted, is connected to the grid through a variable capacitor C_N. This capacitor is always a small unit since its capacitance must be comparable to the grid-plate capacitance of the tube. It is by means of this "neutralizing" capacitor that the amplitude of the neutralizing voltage can be regulated.

Types of Neutralizing Circuits

In the circuit in Fig. 82, the neutralizing voltage is obtained from the plate "tank." As implied above, however, it may equally well be taken from a grid tank as shown in Fig. 83. This circuit, it will be noted, resembles the plate neutralizing circuit of Fig. 82, except that the neutralizing voltage is obtained from a balanced input tank and fed to the plate of the tube. These two circuits represent the two general classes of neutralizing circuits, i.e., "plate neutralizing circuits and "grid neutralizing circuits." Each has its advantages. In these circuits as shown here, the electric network involved in the neutralizing arrangement is shown in heavy lines. As will be noted, these circuits actually form bridge circuits, the grid-plate capacitance of the tube and the neutralizing capacitor forming the two capacitive arms, while the halves of the balanced tank circuit form the other arms.

In both of these circuits, the division of radio-frequency voltage between the plate and neutralizing portions of the circuit has been obtained by balancing the tank coil. The balance, however, can also be capacitive by the use of a split-stator variable capacitor with a grounded rotor, as shown in Fig. 84.

*The term "tank" circuit has been applied to the resonant circuit at the output end of an amplifier—usually a power amplifier, for it is in this circuit that currents of high magnitude are set up, from which the energy is drawn for whatever useful purpose may be desired. It constitutes, as it were, a tank or reservoir of high-frequency electric energy. It is always a tuned circuit.

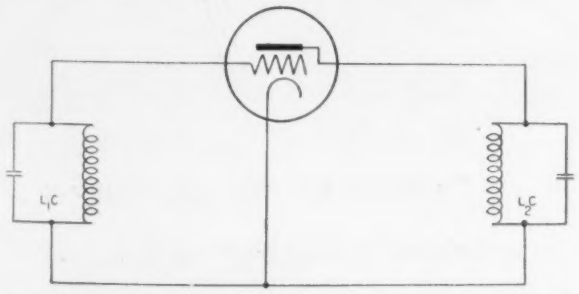


Fig. 81. Tuned-grid tuned-plate circuit. The limitations of this circuit as an amplifier are due to the fact that the tube, by virtue of its interelectrode capacity, acts as a coupling device for the transfer of energy from the plate circuit back to the grid circuit.

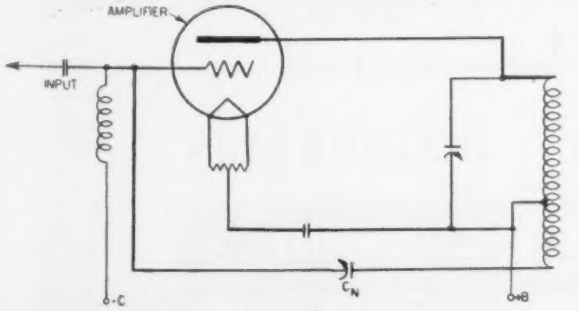


Fig. 82. Circuit showing the method used for neutralizing the capacity effect of the tube.

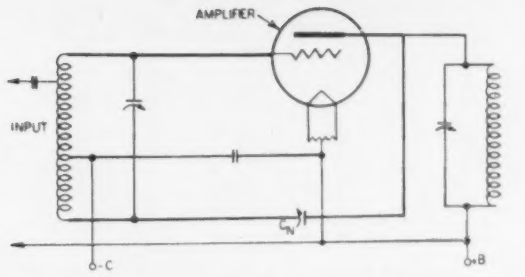


Fig. 83. In this circuit the neutralizing voltage is obtained from the grid tank instead of the plate tank shown in Fig. 82.

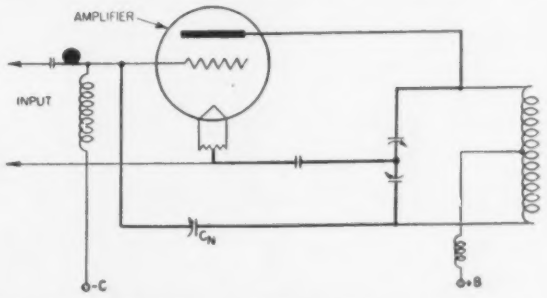


Fig. 84. Here the balance is capacitive and is obtained by the use of a split-stator variable capacitor.

Many other neutralizing arrangements are possible, some of which involve circuits which have not yet received consideration in this book; they will be considered at the time these circuits are discussed, but in all instances the fundamental principles involved are the same. The purpose always is to produce a voltage which will oppose the voltage operating through the grid-plate capacitance of the tube, thus rendering the latter ineffective. In most cases, the neutralizing voltage will be equal to the radio-frequency voltage between the plate and grid of the tube so that for perfect balance the capacitance required in the neutralizing capacitor theoretically will be equal to the grid-plate capacitance of the tube being neutralized. Thus, it is obvious that the neutralizing capacity required at C_N will depend upon the type of tube and the characteristics of the circuit. When two or more tubes are connected in parallel, the neutralizing capacitance required will be in proportion to the number of tubes.

The matter of neutralizing is important only when amplifiers are operated at high frequencies such as those used in radio communication work because it is only at high frequencies that the grid-plate capacity effect of the electron tube becomes large enough to result in the transfer of energy from the plate circuit. The capacitive reactance of any capacitor decreases with the frequency of the current. For illustration, suppose we have an 0.1-microfarad capacitor operating at a frequency of 1000 cycles per second. The capacitive reactance of the capacitor at this frequency can be figured by the following formula:

$$X = \frac{10^6}{2\pi f C_{mfd}}$$

where X_c is the capacitive reactance in ohms
π is 3.1416
f is the frequency in cycles per second
C_{mfd} is the capacitance in microfarads

Substituting our own values in this formula, we have

$$X_c = \frac{10^6}{6.2831 \times 1000 \times 0.1} = 1590 \text{ ohms}$$

Now, suppose we leave all conditions exactly as they are except the frequency; suppose that is changed to 1,000,000 cycles. At this frequency, the capacitive reactance is

$$\frac{10^6}{6.2831 \times 1{,}000{,}000 \times 0.1} = 1.59 \text{ ohms}$$

This simple illustration will serve to show why the capacity effect of the tube elements becomes important at

Continued on page 156

THE KOLLSMAN MARK VI DRIFT SIGHT is a worthy companion to the regular Kollsman line of aircraft instruments. It is used for an accurate determination of drift and ground speed on Navy long range aircraft. Exclusively Kollsman designed, engineered and manufactured... even to the lenses and prisms in its fine optical system... it gives new evidence of Kollsman's versatility in adapting its talents to almost any type of precision engineering problem.

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Vol. III, No. 3 M. F. BEHAR, Editor MARCH 1944

A Time-tested Test on Instruments

By Sr. Acft. Inst. Mech. CHARLES S. BELLIN (Army Air Forces)

IN several past issues of *Instruments* I have noticed pleas for articles on Aircraft Instrument instruction. Although I lack the knack of writing I gathered a group of fifty instrument questions covering all phases and types of Aircraft Instrument work.

In the past I used these same questions on learners as well as mechanics, with amazing results. This "Refresher Quiz" is really a test of definiteness. Often, skilled mechanics can handle an instrument with thoroughness, but when asked to put their finger on definite peculiarities of said instruments they find themselves in a fog.

This test has been given without aid of a text-book, but I soon found that after the test many participants were seeking references on the subjects involved, and *studying* them for the first time.

The time limit is from half to three-quarters of an hour.

PART ONE—TRUE OR FALSE

1. The rate of climb indicator is an altitude indicating instrument. .....
2. Most tachometer shafts run at crankshaft speed. .....
3. The altimeter is an absolute pressure gage graduated in feet of altitude. .....
4. The hydrostatic fuel level gage is so calibrated that it can be used on any gas tank. .....
5. The turn indicator and bank indicator are dependent upon each other in their mechanical operation. .....
6. If the altimeter were set for a given barometric pressure and that pressure decreased, the altimeter would read less altitude. .....
7. Gyroscopic precession is the working principle of the directional gyro. .....
8. The oil temperature gage should read approximately 100°C. before taking off. .....
9. If the turn indicator was rotated 90°, it would indicate pitching motions, and, therefore, would serve the same purpose as the rate of climb indicator. .....
10. The cylinder head temperature will generally run about 20°C. higher than the normal oil temperature. .....
11. The sensitive altimeter indicates the true height above the ground at all times. .....
12. Thermocouple leads consist of double insulated copper wires. .....
13. The Venturi tube of the turn indicator installation should be located outside of the slipstream. .....
14. Air speed indications are greater at higher altitudes. .....
15. When installing a centrifugal tachometer, the excess shafting should be coiled in not less than a 6" circle. .....

PART TWO—FILL IN BLANKS

16. Upon what gyroscopic principle does the turn indicator work? .....
17. Facing the ball tank indicator the ball will be on the ..... side during a right hand skidding turn.
18. From zero to ..... pounds per square inch is the usual calibration on a fuel pressure gauge.
19. The sensitive unit of the air speed indicator consists of a .....
20. The sensitive unit of the altimeter is called the .....
21. The type of fuel level gage that corresponds to a manometer tube is called a ..... gage.
22. The sensitive element of the manifold pressure gage is the same as that of the .....
23. The liquid used in vapor-filled instruments is .....
24. The indicator needle of the turn indicator will point to the ..... during a vertical climb.
25. The approximate speed of the gyroscope in the turn indicator is ..... r.p.m.
26. The turn indicator gyroscope will precess to the left during a ..... turn.
27. The error for which the magnetic compass is compensated is .....
28. The fuel pressure gage uses a ..... mechanism.
29. The most generally used type of air speed indicator is the ..... type.
30. The magnetic needles of the compass are attached to the .....
31. ..... may be used as a damping fluid in the magnetic compass.

PART THREE—ANSWER YES OR NO

32. Do all aircraft engines rotate in a clockwise direction? .....
33. Will the ball bank indicator show the angle between wings and horizon during a bank or a glide? .....
34. Will the turn indicator be affected by pitching motions of the plane? .....
35. Will the centrifugal tachometer work regardless of which way the mechanism is rotated? .....
36. Is a battery necessary in the installation of an electric thermocouple temperature gage? .....
37. Is a manifold pressure gage calibrated in pounds per square inch? .....
38. Can the chronometric tachometer be driven by a flexible shaft? .....

PART FOUR—MULTIPLE CHOICE (pick one out of four and UNDERLINE ONE)

39. How many types of Autosyn Indicators are there? (five, eight, twelve, one)
40. To adjust a Flap Indicators readings one must (correct wiring, install new indicators, coincide transmitter with instrument, put in new fuse)

41. The name "Selsyn" is usually associated with (compasses, radios, bomb-sights, position indicators)

42. An octant is used to (Align Driftmeter, obtain position of aircraft, check gyro precession, check altimeter)

43. An accelerometer is used to (check landing gear operation, aircraft deviation, oxygen supply, measure torque of aircraft)

44. In swinging a compass one usually faces the aircraft first to the (North, South, East, West)

45. A Directional Gyro is sometimes called (Artificial Horizon, Gyro Horizon, Turn Indicator, Direction Finder)

46. The "muscles" of an Automatic Pilot is called the (rotors, cables, oil sump, servo unit)

47. To align a Driftmeter one would use a (transit, binoculars, master compass, pelorus)

48. The damping cylinder in a turn and bank indicator is used to (compensate for temperature, oil ball bearings, remedy pivot friction, regulate precession of the gyro assembly as the aircraft turns)

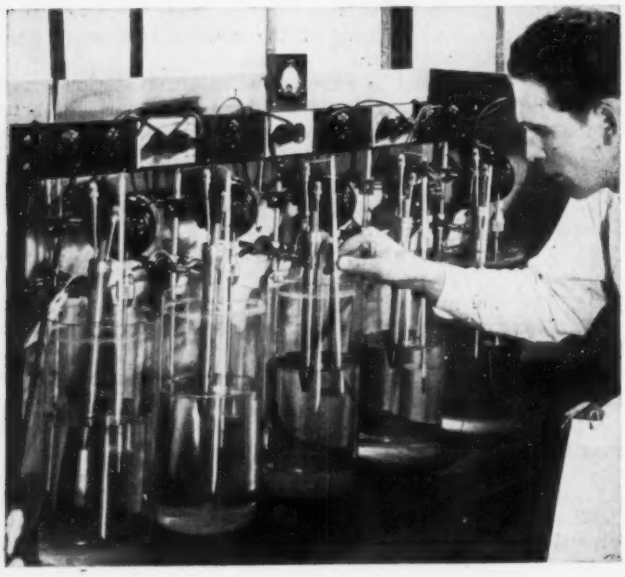
49. To set zero index on a sextant one would use (collimator, transit, manometer, consult weather station)

50. The reason for adding gyro oil to the wick of the turn and bank indicator approx. every 400 hours is (so that the rotor will remain balanced, preserve the life of the bearing, provide proper damping for the inclinometer)

Answers on page 154

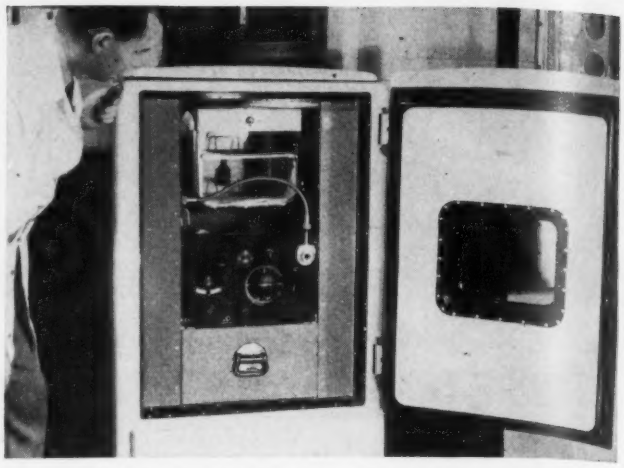
Pitot-static Tube De-icer Tests

DESIGNED for pursuit planes and bombers, Pitot-static tubes for air-speed indicators are shown being tested by an engineer at the Mansfield, Ohio, plant of the Westinghouse Elec. & Mfg. Co. to make sure they will melt snow and ice at high altitudes. Equipped with tiny electric heaters, the tubes must raise the temperature of water a certain number of degrees in a certain length of time to pass inspection. In use, they are attached to the wings or fuselages of planes to produce a pressure differential which is translated into miles per hour on the indicator dial.



You Guessed It at First Glance!

JUST what was it originally, this apparatus for testing aircraft instruments under sub-zero conditions in the instrument shop of United Air Lines' central maintenance base at Cheyenne, Wyo.? You guessed it: a household refrigerator! A vacuum pump and extra electric motor have been installed in the base and a drawer for dry ice is located directly under the shelf on which instruments are tested. There also is a shelf for dry ice above the instruments. The window in the door is a double one with a two-inch air space which keeps it from icing up. Using the refrigerator, instrument specialists are able to obtain temperatures as low as −35°F. with gyro instruments which require air flow and −90°F. with instruments not requiring air flow. In this picture an automatic pilot is shown installed for testing. Results? Well, when those fellows in Cheyenne adopt a testing method and when United's top engineers in Chicago let it be publicized, you can bet it's as satisfactory as if it had been investigated for ten years by Brom's boys at the NBS . . . and in some instances it had been!



AIRCRAFT INSTRUMENT GUILD

INTERNATIONAL HEADQUARTERS

812 N. DELAWARE PLACE
TULSA, OKLAHOMA

The following articles have been contributed by the Aircraft Instrument Guild. For further information on any of the subjects discussed, write to the Guild at the above address.

C.A.A.'s Revision of Requirements for Instrument Overhaul Laboratories

By R. G. OJERS, President, Aircraft Instrument Guild.

IN America's post-war planning, one of the projects contemplated by many instrument mechanics is to own and operate an instrument overhaul department back in their own home town. Those of you with this in mind should consider the Civil Aeronautics Administration's intention of revising the requirements for instrument overhaul laboratories.

A few years ago, in the infant days of aviation, the C.A.A. outlined minimum requirements for instrument overhaul shops that today are completely outmoded—perhaps dangerous.

Now that the wheels of necessity are grinding slowly but surely toward the aircraft instrument mechanic being rated by the C.A.A., let us work toward another factor of even more importance, especially for the civilian owners and commercial operators—that of a sufficiently and properly equipped laboratory.

In many trades, anyone can start a business. In watch-repairing, for instance, any man or woman, if he or she desires, can, with a pair of pliers and some screwdrivers, start overhauling watches and clocks. It isn't against the law and if the quality of the work isn't high, no one is injured. The owner of the timepiece may be late for work or

Checking the alignment of contact holes in a new insert.

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To our customers Cannon Quality Control means *one thing* only—the absolute dependability of Cannon Connectors.

To Cannon men and women, however, quality control means *a thousand things*—the constant vigilance to innumerable details—the continuous betterment of design—the alert scrutiny of materials—the steady improvement of machines, tools and methods—the checking, testing and checking again of all the parts as well as the completed product.

It means following the product into use to measure it against the demands of service. And so Cannon Quality Control results in what you know and appreciate—the uniformity of excellence throughout the multi-millions of Cannon Plugs in service today.

New Training Film on Soldering

An important training aid "Soldering Tips," a 25 minute slide film with sound, giving step-by-step procedure in soldering contacts . . . a companion film for "The Quick Disconnect," available on request. Contact your Cannon Representative or write direct to the Cannon Factory, Dept. A-123.

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Highly sensitive, the Meriam Micromanometer permits readings to plus or minus .001" water pressure. Most rugged, and unequalled in simplicity. Not the least complicated or mysterious, it can be handled successfully by the average operator.

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a business appointment, but no bodily harm is done. A man that is a good salesman can do the same thing with aircraft instruments. It isn't against the law either but, in this case, if the repaired instrument doesn't work, the pilot may meet bodily harm.

So let us consider all angles, safety first, quality, quantity and precision of testing equipment, as we all are well aware that regardless of the ability of a mechanic, his work is useless unless he can properly calibrate and test his completed units. Therefore the laboratory equipment must be right.

Many new instruments are either all-electric or part-electric, which necessitates certain electrical testing equipment not found in even the best repair shops a few years ago.

As a suggestion, please consider the following MINIMUM requirements, bearing in mind that this is to be used as a criterion for discussion, etc. Perhaps there are items we have failed to list, or some may be listed that are not completely necessary in your opinion.

REPAIR STATION EQUIPMENT REQUIREMENTS

Mechanical

Master Mercurial Barometer, temperature-compensated. Also, one Standard Mercurial Barometer (well type) for calibrating, to eliminate the exercising of Master Barometer.

Electric Motor (synchronous-driven).

Turn & Bank Tester.

Dead Weight Tester, Scale range 0-10 lbs.
" " " " " 0-300 lbs.
" " " " " 0-3000 lbs.

Liquid Type Airspeed Testing Manometer.

Manifold Pressure Tester (mercury well type) with substantial type pressure chamber.

Climb Indicator stand (swivel type for position error test and balancing) with liquid type manometers.

Master Stroboscopic Tachometer tester (or similar tester using light for accurate indication).

Temperature calibrating and testing unit for vapor-pressure thermometers (3-container type for cold, hot and room temperature) electrically-heated.

Compass card energizer (minimum 20-amp 225-volt d.c.)

Pelorus for compensating compasses.

Chronometric or railroad watch (16 size 21-jewel or better for airplane clocks).

Demagnetizer for hand tools and instrument parts.

Gyroscopic Overhaul

Necessary special jigs for gyroscopic overhaul.

Grooved lapping blocks.

Surface plate.

Dial indicators of stated precision to meet requirements.

Precision drill press.

9" Power lathe.

Power Grinder.

Large bench vise.

Protected cleaning vat for large parts.

High-volume vacuum pump (capacity, etc., to be specified).

Table Model Scorsby.

Turn-table for Turn Test.

Shop should be air-conditioned to keep down dust and moisture (refrigerant unit to be specified).

Fluorescent illumination to produce "natural light."

Paint spray booth with blower vented outside (to eliminate fumes and paint dust, fire and health hazard).

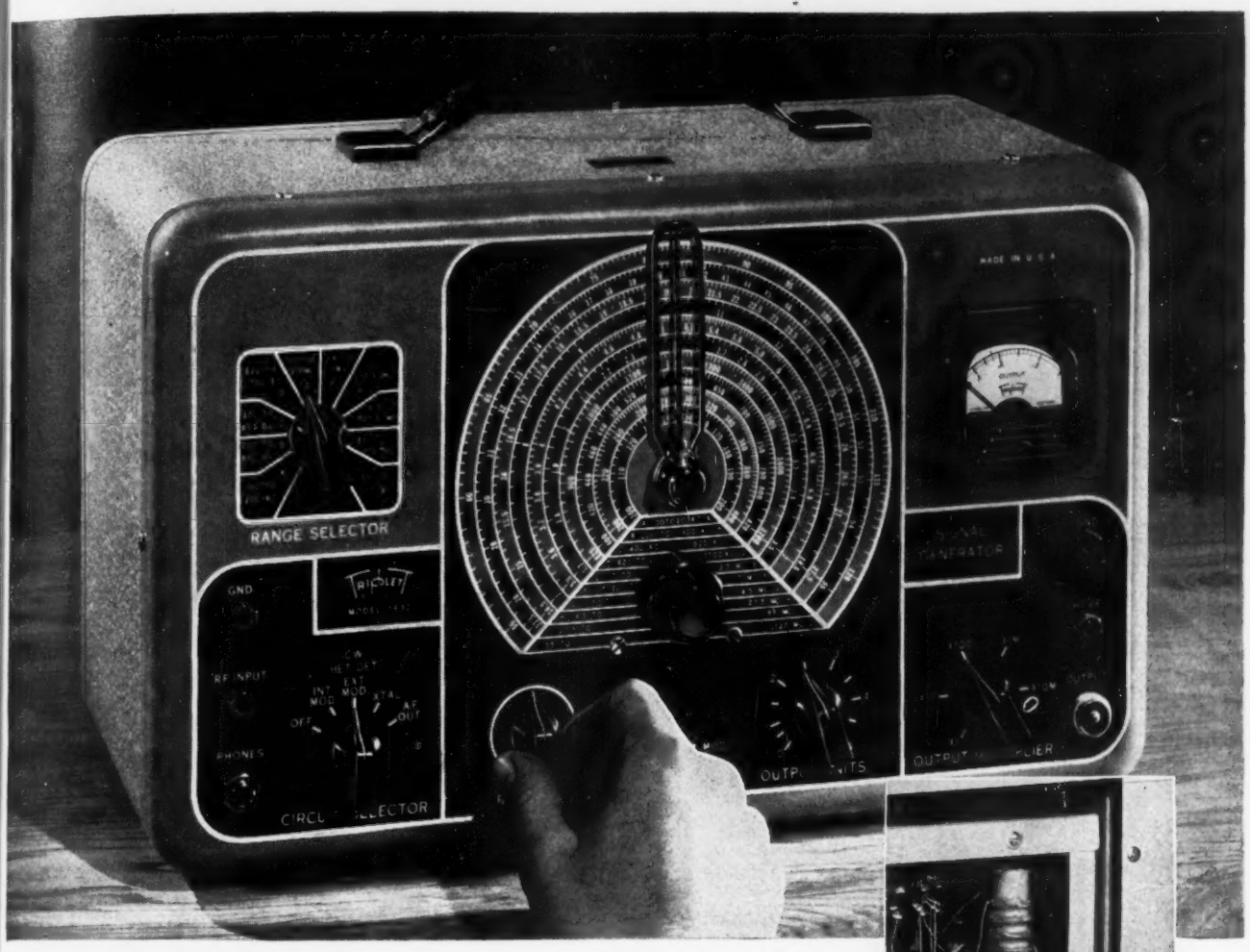
Suitable place for stock of material and jigs.

Adequate supply of air pressure, filtered, for drying of parts.

High-vacuum pump for pressure instruments (specifications to differ from those of large-volume vacuum pump).

Electrical Department

1. Low voltage Supply (24 volts) High Amperage (400 amps)
2. Voltmeter 0-50, Weston Model 45 or equivalent
3. D-c. Milliameter 0-500, Weston or equivalent



MODEL NO. 1632

Signal Generator

CONTINUOUS COVERAGE—100 KC. TO 120 MC. • ALL FREQUENCIES FUNDAMENTALS

A complete wide-range Signal Generator in keeping with the broader requirements of today's testing. Model 1632 offers accuracy and stability, beyond anything heretofore demanded in the test field, plus the new high frequencies for frequency modulated and television receivers, required for post-war servicing. Top-quality engineering and construction throughout in keeping with the pledge of satisfaction represented by the familiar Triplett trademark.

Of course today's production of this and other models go for war needs, but you will find the complete Triplett line the answer to your problems when you add to your post-war equipment.

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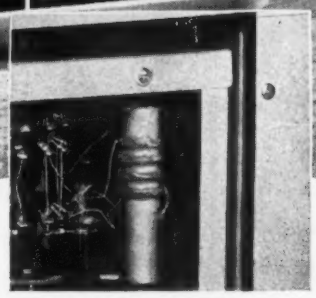
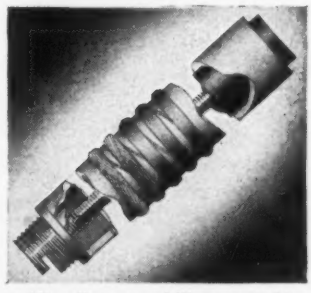
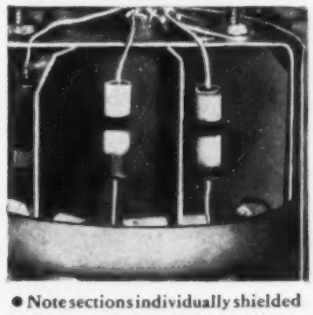
BLUFFTON STANDARDS ARE SET BY TRIPLETT OHIO ★ ★ ★



• Triple shielding throughout, Steel outer case, steel inner case, plus copper plating.



• All coils permeability tuned. Litz wire wound impregnated against humidity with "high-Q" cement.



• Note sections individually shielded with pure copper. Entire unit encased in aluminum shield.

UNIFORM BIMETAL ELEMENTS for CIRCUIT BREAKERS

A uniform size and shape of thermostatic bimetal elements may now be used in the building of a line of circuit breakers covering a wide range of current ratings. This is made possible by selecting a type of bimetal based on the electrical resistivity.

The requirements for such applications are being met by the following types, which cover a wide range of electrical resistivity values.

Electrical Resistivity ohms per cir. mil ft.	Recommended Type of Thermostatic Bimetal
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125	Chace No. 6125
150	Chace No. 6150
200	Chace No. 6200
300	Chace No. 6300
400	Chace No. 6400
480	Chace No. 2400
650	Chace No. 6650
850	Chace No. 6850

The greater activity of Chace bimetals, types 6650 and 6850, permits the designing of smaller units, thus holding weight and size down to a minimum, an important consideration in the making of aircraft controls. For specific recommendations, write us detailing your problem.

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4. D-c. Milliameter 0-1000, Weston or equivalent
5. D-c. Millivoltmeter, Center Bal., 0-5, Weston or equivalent
6. D-c. Millivoltmeter 0-100
7. D-c. Ammeter 0-50
8. Decade Resistance Box 1-ohm steps 1 to 1111 ohms
9. Vacuum-tube Voltmeter
10. Magnetizer
11. Demagnetizer
12. 0-50 Thermal Milliammeter
13. A-c. Voltmeter 0-120
14. A-c. Ammeter 0-50
15. Hot & Cold Temperature Box
16. A-c. Power Supply, Variable Voltage.
17. Analyzer, Standard Type
18. Link-Trainer Test Equipment

Telegon oscillator, 700 cycles, A-c Voltmeter Thermo 0-150 volts. Thermo Milliammeter 0-500. Frequency Meter 650 to 750. Suction and Pressure Controls 400 cycles power supply.

Your cooperation in setting forth your opinions on the necessary minimum requirements of a Government-approved Aircraft Instrument Overhaul Shop is most sincerely sought. This will be especially beneficial to many of you desiring to set up your own instrument shops. There always is a large gap between the minimum requirements and the maximum or ideal, all the time bearing in mind that the minimum requirements MUST be sufficient. Grab a few sheets of paper . . . THINK HARD . . . and send me your list—together with reasons for including new items or excluding some of my items.

Fuel-air Mixture Indicators

By SIMON S. JACKEL, Instructor Aircraft Instruments, Army Air Forces, Yale University, New Haven, Conn.

(*Conclusion*)

PART VI—TROUBLE-SHOOTING

Supplementing the information in Section V, the following may be of assistance in the event of trouble.

1. If no response or "kick" of the pointer results upon switching the current on:

(a) There may be an open circuit in the current supply or the galvanometer wires.

(b) The ballast tube in the indicator unit may be burned out.

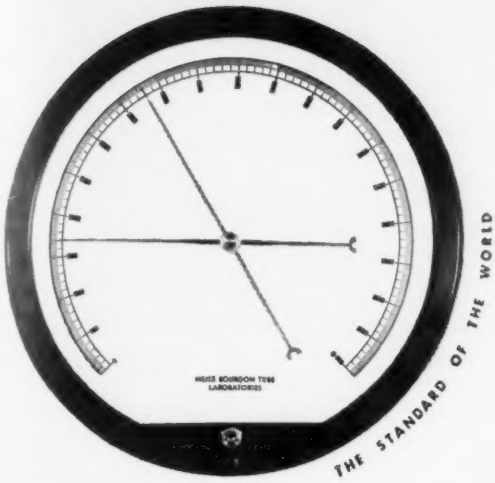
2. If the indicator pointer deflects violently to one or the other end of the scale when the current is switched on:

(a) The wires may be connected up wrongly or there may be a ground. Check all connections and, if in doubt, continuity check all wires between the units to see that they are correctly connected. Make sure no strands of wire are touching adjoining terminals or are grounded. Test for grounds in the usual manner, disconnecting both battery leads. If a ground is not found in the wiring connecting the units, it may be traced to the individual unit by disconnecting the wires to each unit in turn.

(b) There may be an open circuit in the bridge spirals. Inability to set electrical zero (adjusting rheostat reaches the end of its travel) is indicative of this. If the indicator pointer deflects violently against the end stop as the switch is turned on and off at 5-second or 10-second intervals, one or more platinum spirals are probably damaged. To verify that the trouble is in the analysis cell, a spare cell should be substituted and the instrument checked.

3. If the instrument does not properly respond to a change in mixture ratio:

(a) The analysis cell may not be getting a sample of the exhaust gas due to the inlet sampling nipple being improperly placed; water or ice in the sampling system; clogged gas lines or filter; or back pressure on the gas out-



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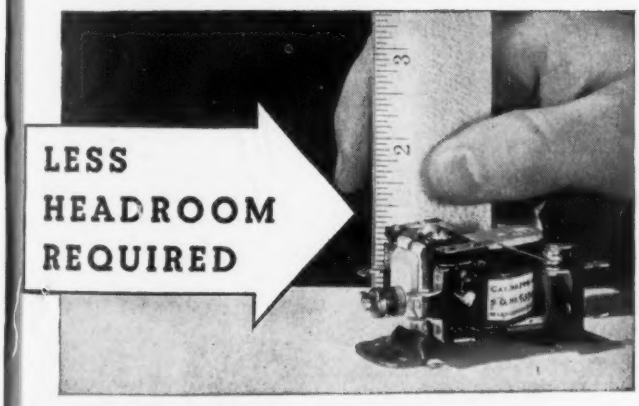

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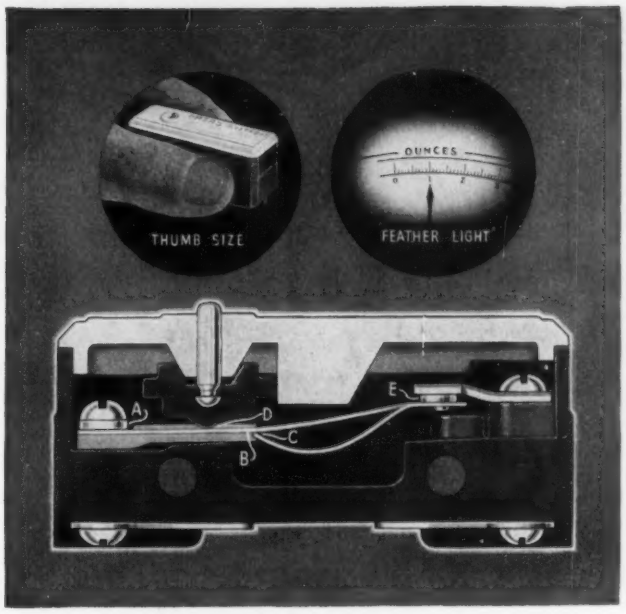

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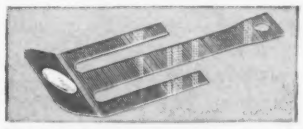
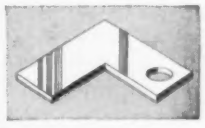
- **Longer switch life than you will ever need**
- **Absolutely precise and accurate repeat operation**
- **40 grams contact pressure—lightning-fast contact action**

The Micro Switch design incorporates features that provide desirable performance characteristics not generally found in snap-action switches . . . The heat-treated beryllium-copper spring bends in the same direction as the operating plunger—no reverse bends—no "oilcan" action . . . gives longer switch life—accurate repeat action—increased contact pressure—lightning-fast action—millions of operations on minute movement and force differentials. It is the choice of design engineers for all types of sensitive instruments.

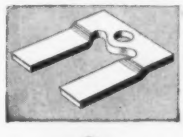


The beryllium-copper spring is made in one piece. It is gauged to an accurate .0085" thickness; has high resistance to fatigue. Ends of compression members are finished to provide an extremely low friction bearing. Contact end of the spring is fitted with a riveted radius type contact of 99.95% fine silver. It moves at a speed of 3/1000ths to 5/1000ths of a second with a rolling action and extremely high pressure.



Stationary contact is a flat inlay of 99.95% fine silver. This construction assures ample over-load capacity and maximum heat dissipation.

Operating plunger is a highly polished stainless steel pin imbedded in an accurately moulded star-shaped Bakelite head. Provides long over-surface path to live parts, thus insuring freedom from electrical leakage. Plunger head cannot rotate within the housing, insuring against any variation in point of operation.



Short spring members pivot in patented V-grooves of this sturdy brass anchor. Note the special shape of these grooves, which reduces friction to a minimum.

If you would like to know more about the Micro Switch, send for the two Handbook-Catalogs illustrated here—No. 60, which covers Micro Switches in general; and No. 70 which deals with specific Micro Switches for use in aircraft. © 1942

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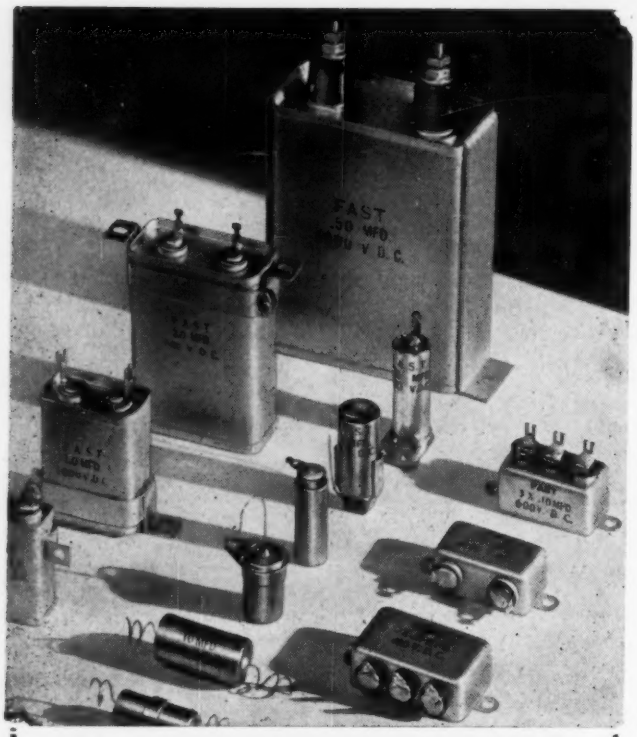

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let from the cell. These points should be checked and corrected where necessary.

(b) The galvanometer wires may be reversed at the connections to the analysis cell. This would cause the indicator pointer to move in a direction opposite to normal.

(c) There may be pivot stiction in the galvanometer or there may be some obstruction preventing free movement of the pointer.

(d) The mechanical or electrical zero may be off. Check in accordance with paragraph 5 and 6, Part V. A temporary shift may take place in the electric zero due to water or other vapors being condensed on a spiral or in the passages. To remedy—remove the filter wool and air the instrument with the current on for several hours, noting whether this restores proper and stable electrical zero. If zero has not been restored, remove the cell from the plane

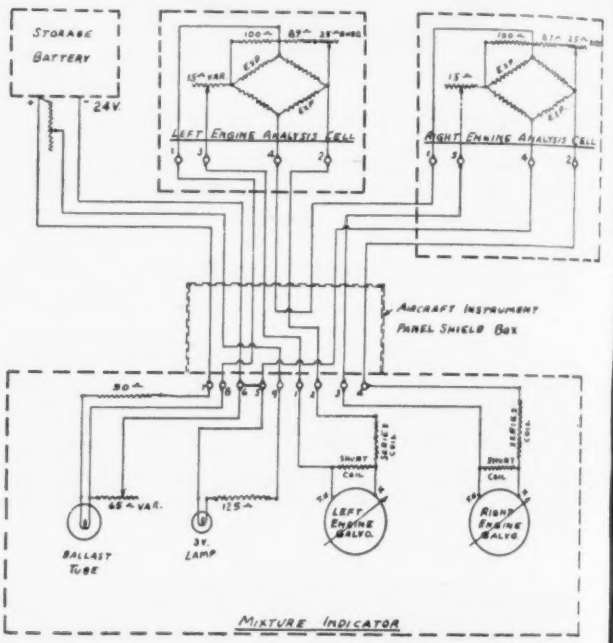

Fig. 11. Electrical Wiring Diagram of Dual-engine Fuel-air Mixture Indicator.

and air for a few days in a warm place not over 52°C. (125°F.) with the filter open and then recheck.

(e) The rheostat brushes and contacts may have become dirty. They should be cleaned and wiped with a clean, dry rag. This may be preceded by wiping off the brush with benzene, if required.

Part VII—Disassembly and Assembly

Disassembly and assembly should be performed by a skilled mechanic only, in a room free from dust and dirt. The manufacturer's instructions should be followed closely, and care should be exercized that no parts are damaged by excessive pressure from the mechanic's hand. Whenever a block of platinum spirals in the analysis cell is replaced, a calibration check must be run. The electrical and mechanical zeros should always be set before calibration checks are made, and the procedure outlined briefly in paragraph 10, Part V should be followed.

The diagrams and resistance values supplied by the manufacturer should always be consulted and checked when trouble shooting or overhauling. The electrical circuit of a Cambridge Dual Mixture Indicator is given in Fig. 11.

In conclusion, the Fuel Mixture Indicator is an instrument that will give excellent service when installed and maintained properly. If used carefully, it becomes a valuable member of the "Invisible Crew" that makes possible safer and more efficient aircraft operation. In this necessarily incomplete article, the writer has tried to establish a working understand of the principles of operation, installation, maintenance, and trouble-shooting. Careful attention to these details will considerably prolong the satisfactory service life of the fuel mixture indicator.

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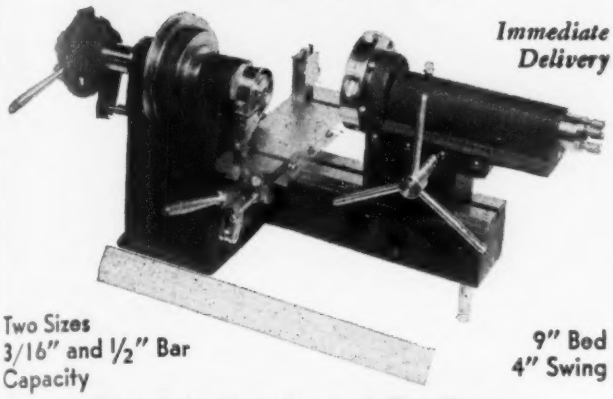

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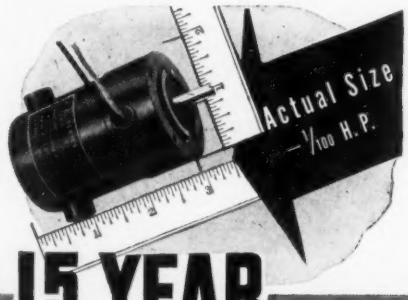

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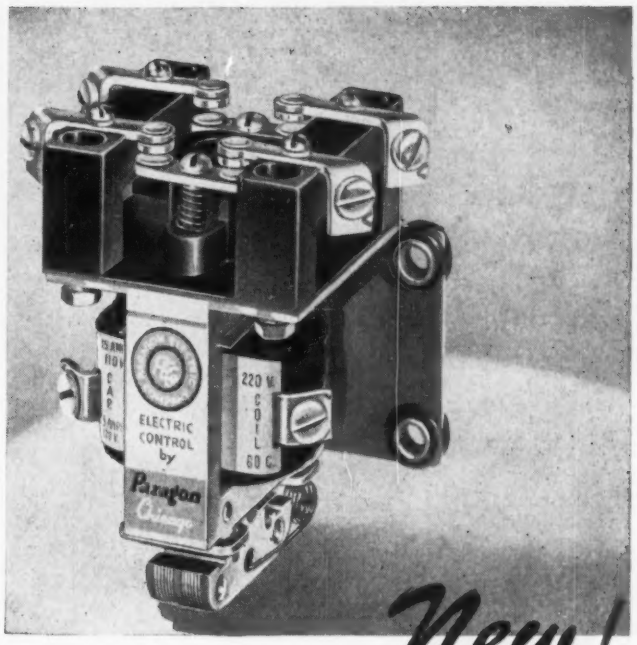

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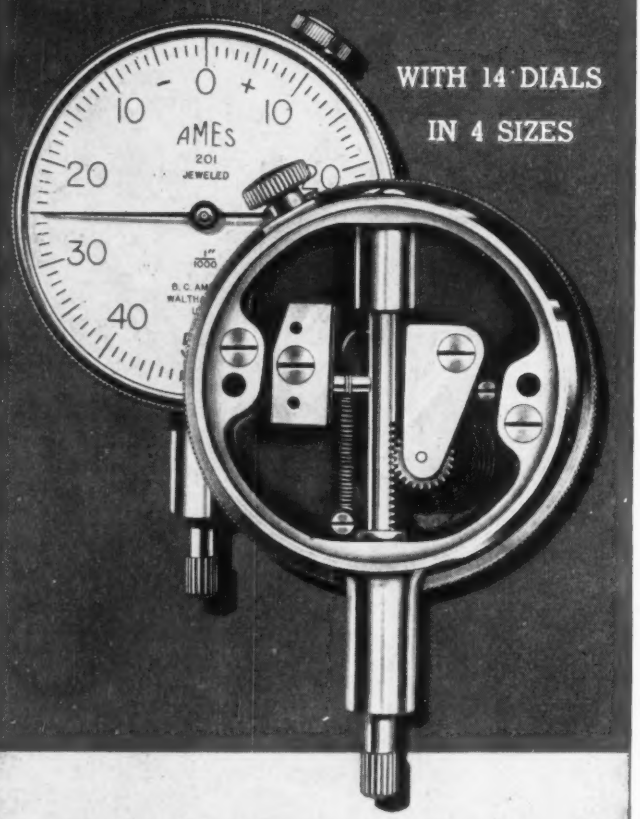

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Jaeger Tachometer Creep Tests

By FRED E. HONEYCUTT, Guild Recorder.

SECTION II

We discussed the Number one test last month. In this article Number 2, 22 and face-down tests will be discussed.

First we turn the tachometer tester on just enough so the Master Tachometer will indicate 200 R.P.M. By placing the instrument on the shaft, turning clockwise for five seconds and lifting it off, we can note whether or not the pointer returns to zero. If it doesn't return to zero, four possible errors might exist which are: (1) Not enough tension on integrator spring. (2) Not enough tension on corrector spring. (3) Too much tension on top forkspring. (4) The center build up too tight.

Now we will shift instrument over to the shaft, turning counter-clockwise and back again on shaft turning clockwise, watching closely to see if the reverse gear has plenty of freedom in reversing. If the reverse gear does fail to reverse or even lag, it has possibly been screwed down too tight. That is, if the instrument is the C-11 type. If it is the C-8 type and it fails to reverse, it has a couple of notches worn on the side preventing it from sliding and reversing, or it might be hanging on bottom bridge. Check for proper freedom.

For the Number 22 test we run the tachometer tester up so the Master Tachometer will indicate 2200 r.p.m. while the tester is running at this speed we place the instrument on the shaft and note the manner in which the pointer ascends. It should not hesitate more than once in ascending to 2200; if it does, or if it goes up to 2100 and jerks two or three times before reaching 2200, the Corrector Spring isn't centralized. If pointer goes up to 2200 all right but falls back to 2150 at times, the Corrector and Integrator Forkspring might be blunted or not enough tension to mesh tightly against wheels. If pointer goes past 2200 at times and falls back to 2200, the Integrator Wheel isn't returning to the stop as it should.

We now lift instrument from the shaft and watch closely to see if the power from mainspring causes the reverse gear to unmesh from Commander Gear. If it does there isn't enough friction in the Reverse Gear. The Reverse Gear in the C-11 type should be tightened down more. If the error is in the C-9 type, a thrust washer might be added. If the mechanism stops running leaving the pointer any place except zero, the error is most likely to be a weak Mainspring. (If Reverse Gear doesn't unmesh with Commander Gear).

The face-down test is to turn instrument face down while it is still connected to tester. In doing this, if there is too much end play in cam-arbor assembly, it will work down, allowing the shoulder immediately below the lower cam to interfere with the lower forkspring meshing with integrator wheel. This error is evident when pointer goes up and drops back to zero at intervals.

END OF AIRCRAFT INSTRUMENT GUILD SECTION

ANSWERS TO AIRCRAFT INSTRUMENT QUIZ

1. False
2. False
3. True
4. False
5. False
6. False
7. False
8. True
9. False
10. True
11. False
12. False
13. False
14. False
15. True
16. Rigidity
17. Left
18. 10 or 25
19. Diaphragm
20. Aneroid
21. Sight
22. Altimeter
23. Menthol chloride
24. Center
25. 12,000
26. Right
27. Variation
28. Bourdon tube
29. Pitot-static or differential
30. Card
31. Acid-free kerosene
32. No
33. No
34. Yes
35. Yes
36. No
37. No
38. Yes
39. One
40. Coincide transmitter with instrument
41. Position indicators
42. Obtain position of aircraft
43. Measure torque of aircraft
44. North
45. Turn indicator
46. Servo unit
47. Transit
48. Regulate precession of the gyro assembly as the aircraft turns
49. Collimator
50. Preserve the life of the bearings.

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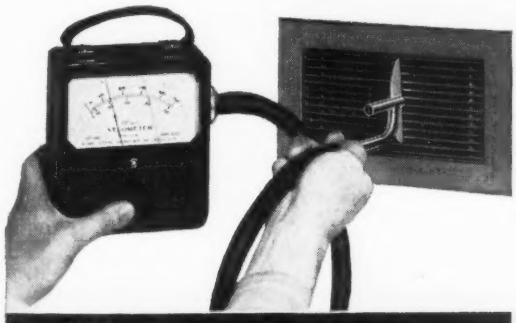

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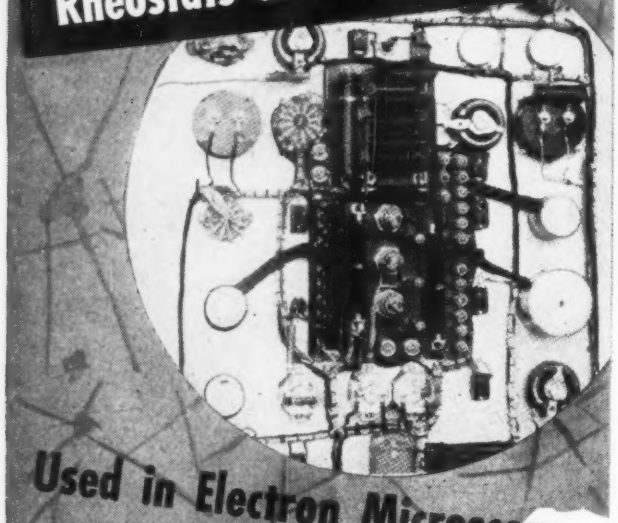
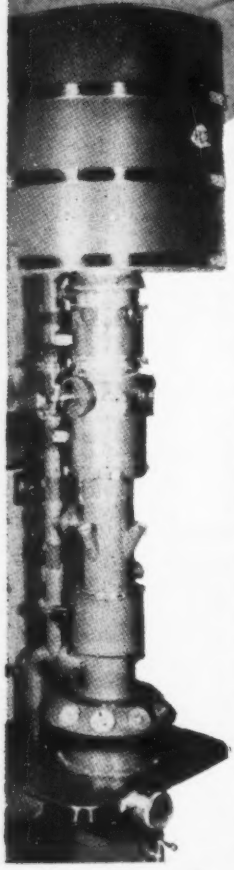
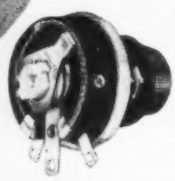


Used in Electron Microscope





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Concluded from page 143

high frequencies. When it is realized that in the communication field frequencies of 1 to 10 or 15 million cycles per second are common, it will be apparent that even extremely small capacitors such as those formed by tube elements present low reactance and therefore pass large currents.

In many industrial instrument applications of electron tubes, however, high frequencies are not the rule and the importance of neutralization in amplifier circuits is diminished. In the case of amplifiers operating at a few thousand cycles per second the capacitance of the tube is a negligible factor since at these frequencies the capacitive reactance of the tube is so high as to prevent any appreciable feedback. A proper understanding of electron-tube operation, however, implies knowledge of neutralization and for this reason it has been considered in some detail here. Furthermore, it has a bearing upon the next phase of our discussion, screen-grid tubes, so from that standpoint neutralization is of interest.

Method of Neutralizing

The procedure involved in neutralizing an amplifier is simple but it should be done accurately if complete neutralization is to be attained. The first essential in the process of neutralization is to have some sort of sensitive radio-frequency indicator: a small neon bulb,* a flashlight lamp with its terminals connected to a loop of wire, or a thermo-galvanometer connected to a wire loop.

Having such an indicator available, the first step in neutralizing is to disconnect the plate voltage from the tube and to set the neutralizing capacitor at zero capacitance. Its cathode should be heated, however, and the excitation from the preceding stage should be fed to its grid circuit. Next, the radio-frequency indicator should be coupled to the plate tank circuit and the plate circuit tuned to resonance—which will be indicated by a maximum reading or indication of the radio-frequency indicator. If a neon bulb is used as an indicator, merely place the metal base in contact with the plate circuit.

Now with the plate circuit still tuned in resonance and the indicator in action, gradually increase the capacitance of the neutralizing capacitor. This will cause the indicator

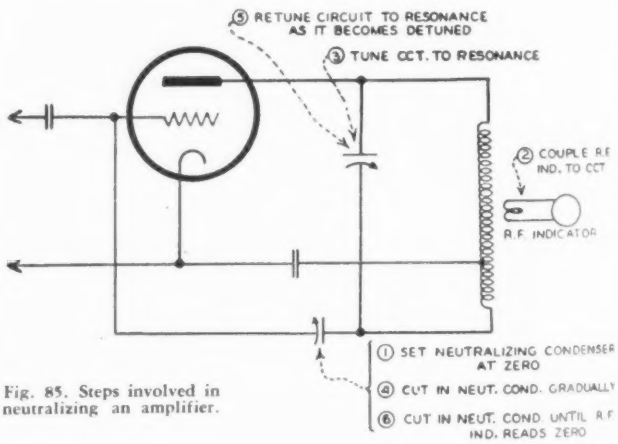
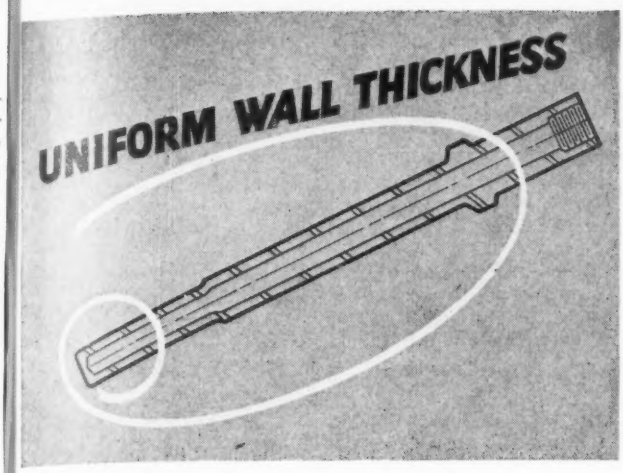

⑤ RETUNE CIRCUIT TO RESONANCE AS IT BECOMES DETUNED
③ TUNE CCT. TO RESONANCE
② COUPLE R.F. IND. TO CCT
R.F. INDICATOR
① SET NEUTRALIZING CONDENSER AT ZERO
④ CUT IN NEUT. COND. GRADUALLY
⑥ CUT IN NEUT. COND. UNTIL R.F. IND. READS ZERO

Fig. 85. Steps involved in neutralizing an amplifier.

to register less current. This process may throw the plate circuit slightly off resonance so it may be necessary to readjust the tuning capacitor slightly so as to bring it back to resonance. Continue to turn the neutralizing capacitor until, finally, a point is reached where no further indication of radio-frequency current is obtained. When this point is reached the circuit is properly neutralized. These steps are indicated in Fig. 85.

As has been mentioned, perfect neutralization cannot be maintained over a wide band of frequencies because leakage inductances and stray capacitances prevent the neutralizing current from being exactly proportional to, and exactly out

*A small ¼, ½ or 1 watt bulb such as are used as indicating lamps on 110 v circuits will serve nicely for this purpose.



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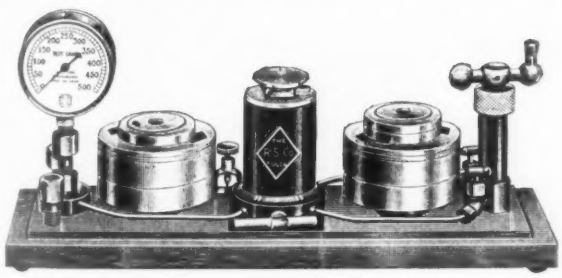

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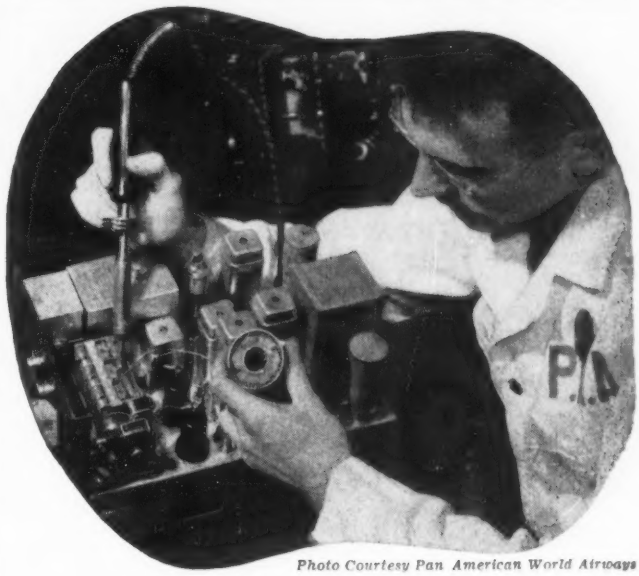

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of phase with the current through the grid plate capacitance at all frequencies. Imperfect neutralization results in a certain amount of regeneration but ordinarily it is possible to maintain a balance which will give stable performance of a radio-frequency amplifier over a range of several million cycles per second; which of course is sufficient for most ordinary purposes.

Dead-weight Calibrating Machines

TESTING MACHINES for determining the strength and other properties of structural materials are liable to error as is every other weighing mechanism. To meet the need for a convenient, accurate, and portable device for determining these errors the Whittemore-Petrenko proving ring was developed by H. L. Whittemore and the late S. N. Petrenko of the engineering mechanics section in the National Bureau of Standards. The proving rings themselves must be calibrated, and a dead-weight testing machine of 102,000 lbs. capacity was installed at the Bureau in 1927. The widespread and growing use of proving rings for checking testing machines in service and for adjusting the weighing systems of new ones has greatly increased the calls on the Bureau for calibrating these rings.

Fifteen years' experience in using the dead-weight machine forms the basis of *Bureau of Standards Circular C446*, prepared by Bruce L. Wilson, Douglas R. Tate, and George Borkowski. In using the machine, as originally installed, it was found necessary to apply 8 or 10 different test loads to determine the relationship between the load and the readings of a calibration device. Although test loads from 2,000 to 102,000 lbs. by 10,000-lb. increments could be applied, the machine was found to be inadequate for calibrating devices having capacities less than 100,000 lbs. A new and smaller machine was therefore installed for test loads from 200 to 10,100 lbs. by 100-lb. increments. The large machine is now used for loads from 2,000 to 111,000 lbs. by 1,000-lb. increments.

The errors of the weights were determined after the machines had been in use for several years. The maximum error of any of the weights was less than 0.01%, and it is believed that their stability is such that the errors will not, under normal circumstances, exceed 0.02% for a period of 10 to 20 years.

Copies of *C446* are obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 5 cents each.

Measuring the Degree of Curl of Paper

THE tendency of paper to curl is a source of trouble, particularly in feeding sheets through automatic machinery. Curling may result from a strain in the sheet acquired during manufacture, or from some maladjustment arising from exposure to moisture in the atmosphere, or drying, which makes one part of the sheet expand or contract more than another part.

Curling is promoted particularly by a difference in expansion or contraction of the two surfaces, resulting from conditions of exposure, nature of the surfaces, or a combination of both. Simple laboratory tests may aid in choosing remedial measures; a common test is to note the maximum amount of curl resulting when a small piece of paper is floated on water. A study of this test has recently been made by Frederick T. Carson and Vernon Worthington at the National Bureau of Standards. Several modifications of the flotation apparatus and method were devised in an effort to evaluate curliness in terms of maximum curvature. In *Research Paper 1522* in the Feb. 1943 *Journal of Research* of the Bureau, data are given to show how curliness determined with the curl sizing tester agrees with that determined by an optical method. Good correlation of curliness was found with density, expansivity, sheet shrinkage during fabrication, and air permeability.

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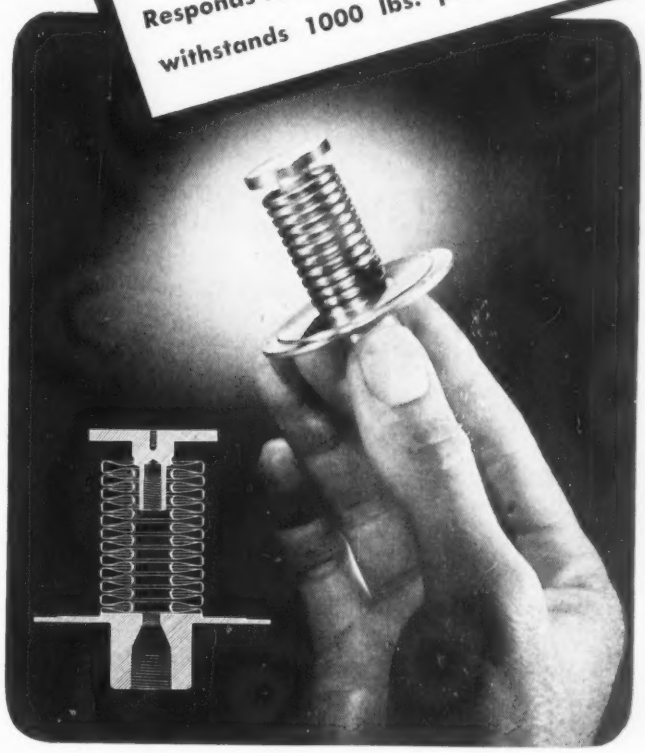

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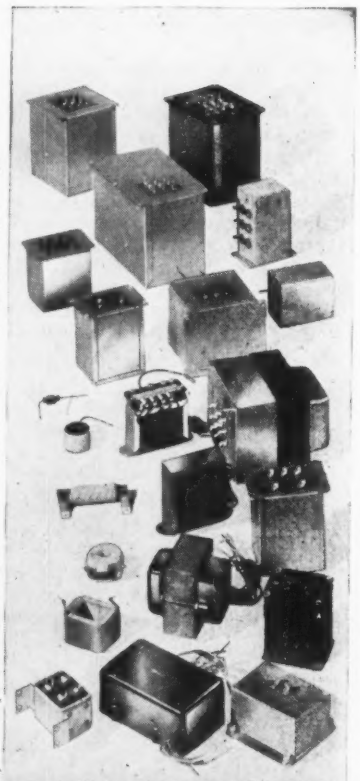

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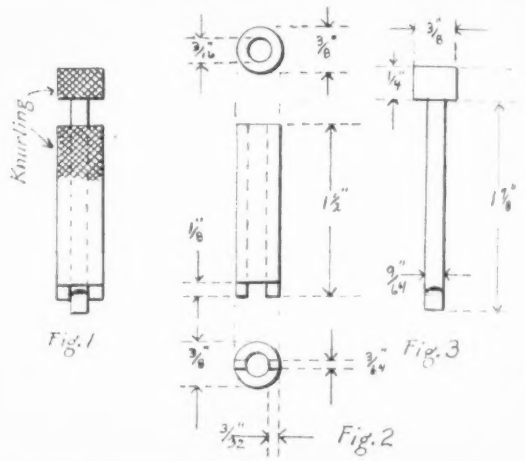
By RALPH BLANKENSHIP
Instrument Repairman, Public Service Co. of Indiana, Inc.

HERE is a special wrench, which is easy to make and is useful to instrument repairmen who repair portable and switchboard voltmeters, ammeters and wattmeters. The jewels [jewels assembled in screws] in some of these instruments are held in place by a round lock-nut which has

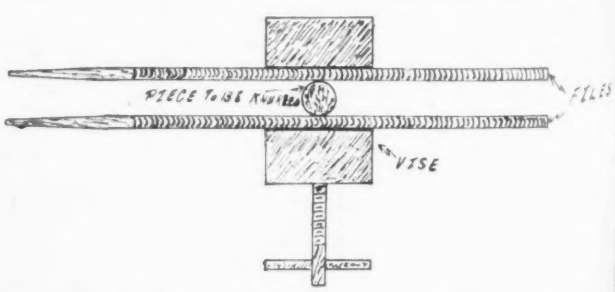


two slots for a special tool. The repairman must be careful in replacing the jewels, so as not to get them too tight. That is a hard job to do without a tool to hold this nut and also the jewel screw. Fig. 1 shows the finished wrench with the small screwdriver, which goes in the center of the wrench to hold the jewel screw. Fig. 2 shows the wrench and Fig. 3 shows the screwdriver. Since I made this wrench my troubles are over in replacing jewel screws with this type of lock-nut.

Knurling Small Tools

By RALPH BLANKENSHIP
Instrument Repairman, Public Service Co. of Indiana, Inc.

INSTRUMENT men sometimes want to put a knurl on a small tool they are making. Nowadays, tools are hard to get; or there may be no lathe to use a knurling tool in. Here is an idea which did a fair job of knurling for me.



I took two flat mill bastard files and placed them in between the jaws of the vise. In between the files I placed the piece of steel to be knurled and closed the vise. Then I loosened the vise and turned the piece; and repeated till I had been around the piece. If the knurl wanted is short, you can block up under the piece till you get the right length desired.

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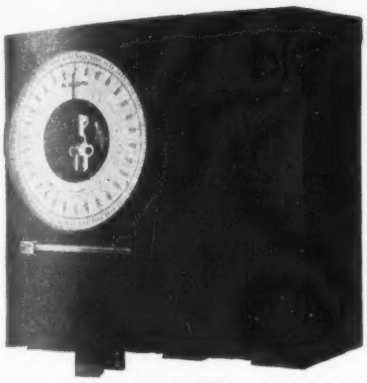

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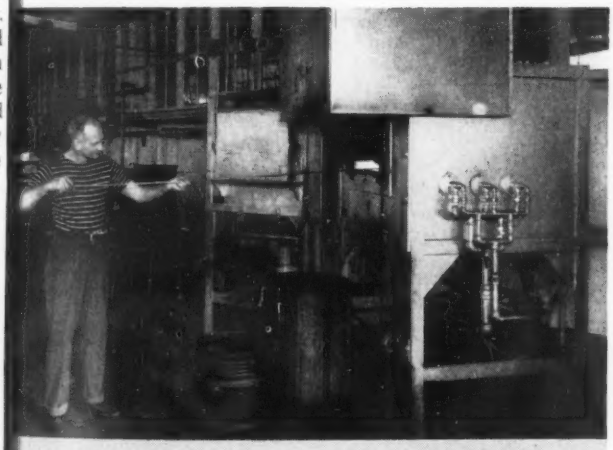

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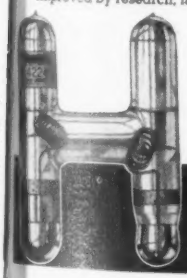

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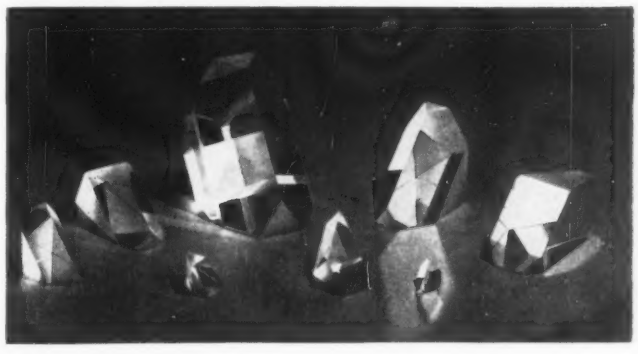

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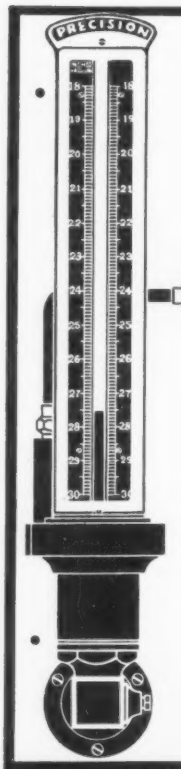

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New Electronic Relay Method

(Concluded from Page 133)

in the blocked position. Motors of this kind are available on the market.

For controlling temperatures by this method, the contacts may be operated by means of a conventional bimetallic strip. Since the operating cycle for the contacts requires a motion of only 0.0001", a high order of sensitivity can be obtained even with the ordinary bimetallic strip. This sensitivity can be illustrated by means of the follow-up unit described above, altered as shown in Fig. 3. The manually-operated micrometer is turned back out of the way and a contact carried on the end of a bimetallic strip about 2" long is interposed instead. The motor is then removed from the stand and the movable contact brought up manually until the motor just begins to rotate in one direction. By bringing the thumb within one inch of this bimetallic strip, the temperature of the strip is changed sufficiently to cause the motor to reverse. The temperature change in the bimetallic strip, in such an experiment, must be very small indeed.

Another demonstration of the sensitivity of the new electronic method was made by means of the apparatus shown in Fig. 4. A lamp was connected in the output circuit L_2 and placed inside a small box near a bimetallic strip operating the actuator. The strip was so arranged that if the temperature went down, the contact opened causing the lamp to glow. The response of the

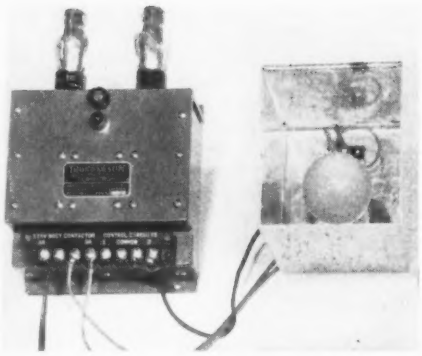

Fig. 4

bimetallic strip was so rapid that the lamp would go off and on many times a second. Even blowing on the outside of the box would result in a sufficient change of temperature inside to cause the operating cycle to be altered. This further illustrates the extremely small contact travel required to cause a definite off-and-on operation of the unit connected in the output circuit.

These experiments will show the possibilities of the method for those applications in which the operation can be obtained by means of the opening or closing of contacts. The fact that the contacts can operate through a high resistance would make it possible to operate these contacts from mercury or other conducting liquid levels. An interesting experiment results when contact is made with the surface of ordinary tap water. If the contact unit is motor-operated and so arranged that the contact is pulled out of the liquid as contact is made, it will pull up a film of liquid to a height determined by the surface tension of the liquid. When the film of liquid breaks, the motor will reverse, driving the contact back into the liquid. With ordinary tap water it was found that a film about three hundredths of an inch long was always pulled up. The addition of a small amount of wetting agent would reduce this film height to about two-thirds of this value. These factors of capillarity and surface tension must be kept in mind in applications in which contact is to be made directly with a liquid level. Where this action would be troublesome, it can be eliminated by making a contact with a float on the liquid rather than with the liquid surface itself.

CONCLUSION

The foregoing is sufficient to show that this method should find wide application in industrial control operations. It must be pointed out, however, that the extremely sharp response may result in undesirable hunting action which may have to be overcome by some external means. For example, if the contacts are placed on some element which has a large amount of inertia, it is possible, under certain conditions, to set up wide oscillatory motions in the restoring mechanism. Appropriate attention to design of the other units should, however, make it possible to overcome such difficulties.

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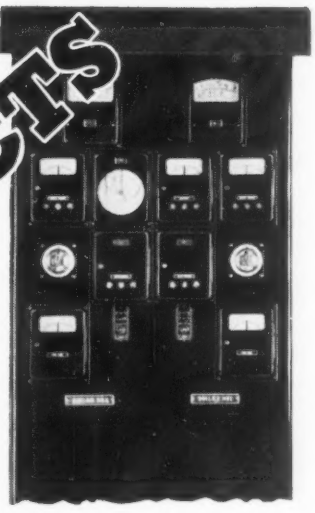

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METALLOGRAPHY. By CECIL H. DESCH. 5th Ed. Longmans, Green & Co., New York, 1942. Cloth, 5½ × 8½ inches, viii + 408 pages. 149 figures. Price $8.00.

The first edition, published in 1910, was the first outstanding textbook on the subject, if not the first. It was thoroughly thumbed by this reviewer and successive editions have been studied by countless inquirers after information on the structure of metals, to their great benefit. The influence of a good textbook can be widespread. Despite the plethora of similar books by later authors, Desch remains well up around the top of the list.

It has always been more a book for the specialist in metallography, both ferrous and non-ferrous, than for the engineer seeking metallurgical data, since it relates to structure, to the principles controlling structure and to the technique of revealing structure with one secondary consideration of the properties resulting from different structures.

Considerable emphasis is placed on laboratory instruments, tools and methods, on the precautions necessary in their use and on the limitations in interpretation of results.

The present edition seems to be the same as the 1937 edition, with the addiiton of six pages of appendix. The appendix has not brought the contents entirely up to date, for example the 1937 discussion of electron diffraction methods and of the electron microscope could well be augmented. The Knoop diamond for hardness testing is not mentioned. The appendix brings in brief comment on electrolytic polishing and on S curves, and other points minor in character. Few topics are treated in sufficient detail to satisfy one seeking a complete picture, but many references are given, mostly to publications of English workers. Yet, before going to other sources for a fuller discussion, it is well to read Desch, for he hits the high spots with clarity and logic. The book represents more than three decades of careful thought by a master, not only of facts, but also of presentation.

—H. W. GILLETT, *Technical Adviser, Battelle Memorial Institute, Columbus, Ohio.*

THE PHYSICS OF METALS. By FREDERICK SEITZ. McGraw-Hill Book Co., New York, 1943. Cloth, 5½ × 8½ inches, viii + 330 pages. Price $4.00.

In this book the author sets for himself the difficult task of writing "for metallurgists with a limited knowledge of physics and physicists with a limited knowledge of metallurgy." He has done this very well and has provided a book which makes an excellent "Rosetta stone" for both groups.

The book is divided into 21 chapters which can be classified into four main sections. The first, containing the first 5 chapters (69 pages), is a review of background that should be common to both physicists and metallurgists. This section contains many fundamental definitions and concepts and discusses such subjects as crystal structures as revealed by x-ray, the periodic chart, the fundamental thermodynamics of metals and alloys, and the elastic properties of crystals.

The second section, consisting also of 5 chapters (104 pages), is primarily concerned with the plastic properties of metals. This section is possibly a little longer than might be expected from the concise presentation in the first five chapters; however, it reflects a vast and confusing literature and can be read with profit by both metallurgists and physicists. Subjects discussed include the plastic properties of both single crystals and polycrystalline media, creep and secondary plastic effects, internal friction, rupture and fatigue.

The third section, consisting of three chapters (56 pages) is written mainly for physicists in the sense that the subjects discussed are found more often in metallurgical than in physical journals. These chapters discuss diffusion in metals, the effects of gases in metals and an elementary discussion of iron-carbon alloys.

The fourth section contains 7 chapters (91 pages) and is written for the metallurgist. It starts with an elementary discussion of the concepts of modern physics and proceeds from there to a discussion of contributions physicists have made to the understanding of metals. The discussion includes brief description of the electron theory of metals, the band theory of solids, the cohesion of solids, the constitution of alloys and the magnetic and electrical properties of metals. This last section is particularly well written and is invaluable to a metallurgist searching for an entry into the literature of physics.

The book should be a welcome addition to any scientific library.

—L. R. JACKSON, *Research Supervisor, Battelle Memorial Institute, Columbus, Ohio.*

MAINTENANCE AND SERVICING OF ELECTRICAL INSTRUMENTS. By JAMES SPENCER. Edited (and portions written) by M. F. BEHAR. The Instruments Publishing Co., Pittsburgh, 1944. Cloth, 5 × 8 inches, xii + 256 pages, 274 illustrations. Price $2 postpaid.

Every once in a while the gods smile with favor upon a chosen few, and this time they favor instrument people in the form of Mr. Spencer's book.

Whenever looking through a new book, I usually determine the scope of the contents, so naturally the same question arose as I began reading "Maintenance and Servicing of Electrical Instruments." Will this book cover only a portion of electrical instrument repair work, or will it truly give a broad coverage which will make it more than worthwhile to the service men? Imagine my satisfaction when, as I digested the pages, I found that the book not only affords a good coverage of electrical instrument repair work, but, in addition, gives servicing methods and "kinks" which only a man in the industry with years of experience would know. I can safely say that the "kinks" and repair hints in the book alone justify its publication. But the author was not satisfied to leave it alone at this because he has also included some theory; not too complex, but theory that every service man should know to be successful in his line of work.

Organization of the material is commendable. I like the method of taking an instrument as to principle of operation, explaining the theory behind it in simple language, and following this with inspection procedure and suggestions on repair and maintenance of the instruments. This makes the book much clearer, and affords a quicker method of finding helpful suggestions and aids from the standpoint of a service man who uses the book in his work. This treatment also prevents confusion from the reader's standpoint.

After studying the contents of a new book, I usually consider the illustrations —photographs and diagrams—because one of the best methods of teaching a subject, or explaining a subject, is through the medium of photographs, charts, etc. While we may be suffering from a shortage of many things under wartime conditions, I am glad to find that Mr. Spencer's book has not followed this pattern by keeping photographs and illustrations to a minimum. The basic principles of each class of instrument are well illustrated; circuit diagrams and hookups are adequate to give the reader a knowledge of connections required for specific measurements; and, for the first time as far as I can determine, application charts and trouble charts are presented. All of these add to the attractiveness of the book and, needless to say, help the reader

in understanding and remembering more easily the written words.

Without a proper index, a book becames practically worthless as a reference tool. I was surprised to find over 1800 entries in the index. This proved to me that someone had spent a considerable amount of time in working up an index which was made to be used. Just to try it out, I assumed several hypothetical repair cases, trying to put myself in a position of a repair man who desired to use the book as a reference and guide. Within a very few seconds, I was able to find sufficient references to give me all of the information I wanted to know and this proved to my satisfaction that the index has been designed for use and not merely to abide by the rules of textbook publications.

I found M. F. Behar's chapter on "Pivots and Bearings" quite interesting. Needless to say, this definitely adds to the attractiveness and practicality of the book. Here again the information has been based upon years of experience in the electrical instrument field, and the reader can gain, within a few minutes, information on instrument repair which has taken years and years of experience and hard work to discover. This chapter tells the repair man practically everything about pivots and bearings he needs to know in his line of work, and covers everything from materials used in bearings and pivots to inspection and grading of sapphire bearings.

In this chapter the part on vibration should not be under-rated. In this ever-increasing tempo of wartime conditions and combat work, we are faced more and more with the problem of vibration and its effect upon the life of the instrument. Every service man should be familiar with vibration and its effects, even if only in a small way. A good portion of his work can quite possibly be the result of vibration, especially when the service man or repair man is in the Armed Forces.

Before coming with the War Production Board, I had spent a number of years, in fact my entire career, with one of the leading electrical instrument manufacturers of the country. I can say without hesitancy that I have never before seen so much information on maintenance and repair of electrical indicating instruments in any one book. I wish to take this onportunity of congratulating Mr. Spencer, Major Behar, and the Instruments Publishing Company for the fine job they have all done. There is no doubt that this book will be found in the hands of all instrument men, whether service people or not, because it is full of information that we should all know and have at our finger tips every hour of the day.

—HARVEY P. ROCKWELL, JR.
Washington, D. C.

AN INTRODUCTION TO CONTROL ENGINEERING. By ED S. SMITH. Published by the author, 200 Edgemont Place, Teaneck, N. J. Paper, 8¼ × 11 inches, in two parts: part 1 (text) 113 sheets mimeographed on one side, part 2 (figures) 28 lithoprinted pages. Price $2.00.

To paraphrase Lewis Carroll, "The time has come," the author said, "to write of many things."

Having come to that conclusion, Ed Smith has written of many things associated with control engineering, but in a regrettably brief manner.

In spite of the word "Introduction" in its title, this book is by no means elementary. It will be most useful to those who have already become acquainted with the field of control engineering through reading and through practical experience. A man who has devoted his own effort to the understanding of dynamic phenomena which so frequently interfere with satisfactory control can enter this book with a mighty resolve and emerge with a method by which he can reach a solution to his problem.

In the interest of brevity the author has condensed his thought to such an extent that a reader must already have gotten his own thinking "into the groove" in order to follow many parts of the book. The reading of it is in itself a problem in control—men-

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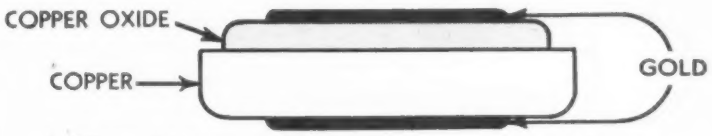

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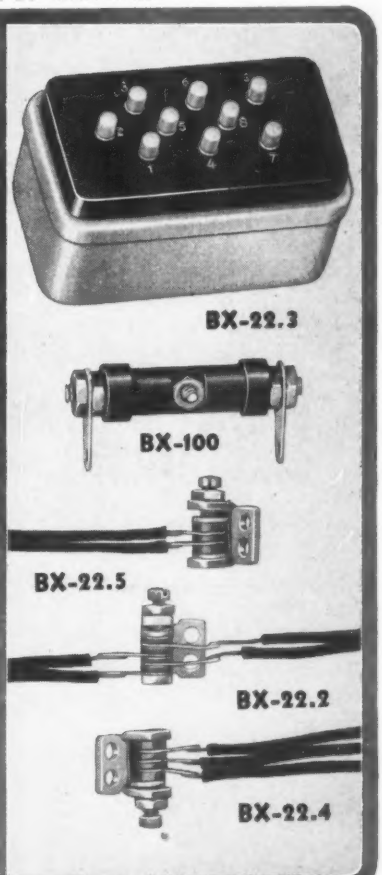

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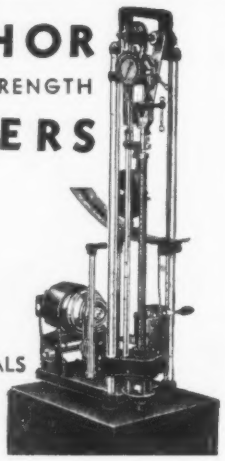

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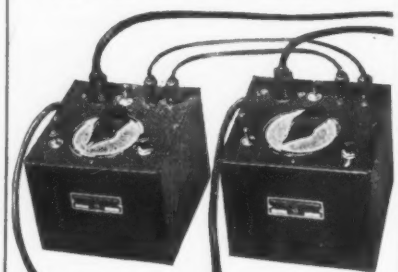

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tal control—but no doubt less difficult than the one the author faced!

The content is valuable material—definitive, descriptive, expository. It can only be the result of long experience and study, phenomenally wide reading, and years of association with the other outstanding leaders in the control field. It will serve excellently as handbook material. In the reviewer's opinion, the volume would be better termed a "Handbook of Control Engineering." A part which can be regarded as a distinct personal contribution of the author's is the section on quantitative analysis of regulated *systems*, comprising plant and regulator in combination. By means of five schematic system diagrams, twelve pages of text and a handily arranged table, 32 combinations of plant and regulator conditions are analyzed and tabulated in mathematical terms. All symbols have been reduced to a common basis, which shows that seemingly unlike combinations of plant and regulator may actually be parallel in their control responses.

The classification accomplished by this table should be valuable to control designers in their search for the best combinations to accomplish certain ends. To the control application engineer, the table is valuable as a check list which can be used to identify the theoretical nature of a new situation, and to recognize the functional nature of various control mechanisms which are available.

To management, this portion of the book illustrates the degree of complication which may be involved in any new control situation. Generalizations are rarely trustworthy in this complicated field.

Sections on physics and mathematics largely duplicate other sources, but they show the worker in control just what principles and methods can be most useful to him and where he can find the necessary material. A simplified step-by-step method is explained, for handling problems which would otherwise require the solution of higher order differential equations. Throughout the book numerous references appear. At the end there is a replete bibliography.

In a separate 26-page booklet the reader can find schematic diagrams illustrating many typical situations, to save him concocting analogies for himself.

—W. B. HEINZ, *Consulting Engineer, Bound Brook, N. J.*

A-C CALCULATION CHARTS. By R. LORENZEN, John R. Rider Publisher, Inc., New York, 1942. Cloth, 9¾" × 12½", 146 pages. Price $7.50.

A means for rapid and accurate calculation of the quantities involved in alternating-current circuits is an important engineering aid. This book attempts to provide such a means. It consists chiefly of the by-now familiar capacity-inductance-reactance-frequency charts and their less common counterparts with reactance replaced by susceptance. Each of these charts is ruled logarithmically in the horizontal and vertical and in two diagonal directions. The abscissae give frequency, the ordinates reactance or susceptance, and the diagonals inductance and capacitance. Thus each point determines a set of quantities in the pair of equations

$$x = 2\pi fL = (2\pi fC)^{-1}$$
$$\text{or } B = 2\pi fC = (2\pi fL)^{-1}$$

either of which includes

$$f = [2\pi(LC)^{1/2}]^{-1}.$$

This type of chart, of course, is not original with the author and he gives in the introduction a short history and bibliography of it besides outlining its theory and usefulness.

The author's contribution lies principally in providing charts of slide-rule accuracy and eliminating, insofar as possible, decimal-point errors. The first is obtained by using a 6¾" square for a decade and printing the lines on good quality glossy paper. The second is obtained by using one chart per decade with the decimal points given in the scale values. Thus there is no ambiguity on any chart.

Definition has a price. In this case 144

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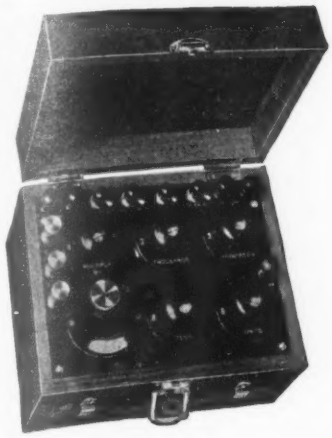

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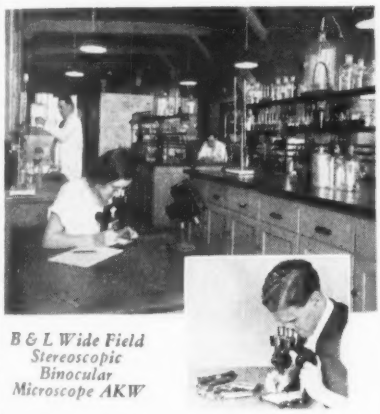

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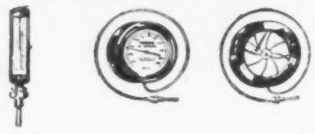

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charts, 72 giving reactance and 72 susceptance, are required to cover the rather extensive range the author decided on. In addition a master chart for each of the 72 is provided as index. The charts cover reactances from 0.01 ohm to 10 megohms and frequencies from 10 cycles to 1000 megacycles. Inductance and capacitance naturally cover the sum of these ranges in decades.

Each chart besides the log-log graph carries a reactance-susceptance inverse strip like the *C* and *CI* scales of a slide rule and a square-square root strip like the *A* and *D* scales of a slide rule. These are used in getting complex impedances when resistances and reactances are given. In the rear of the book are a chart giving *Q* as the ratio of *X* to *R* or *B* to *G* and a strip of arctangents in degrees for numbers from 0.1 to 1000 for phase angle determination.

The value of the book depends, as with any tool, on the quantity of work to be done with it and its superiority over other tools. The slide rule and an index chart for the decimal point with a single decade chart for precision are alternatives. The use of two colors, red and green, for the superimposed log-log scales aids speed and precision, making the book considerably faster to use than the slide rule. Automatic location of the decimal point is an advantage over a two-chart system, especially if excessive skipping from chart to chart is not required.

The volume is handsomely and ruggedly bound as befits its use, and the two colors are aligned on the charts with sufficient precision.

—G. S. LEY, *Engineering Dep't, Radio Div., Westinghouse Elec. & Mfg. Co., Baltimore, Md.*

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(Appeared serially in *Instruments* from August 1941 to June 1943

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In charge of Instrument and Relay Department, Meter Division, Westinghouse Elec. & Mfg. Co., Newark, N.J.

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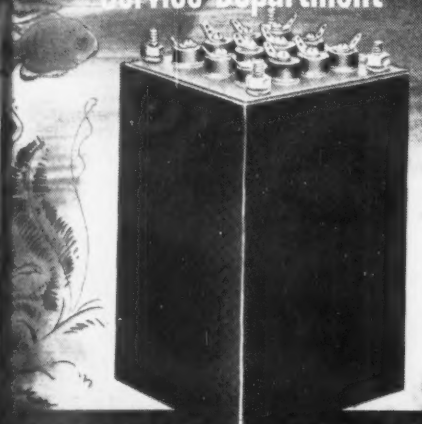

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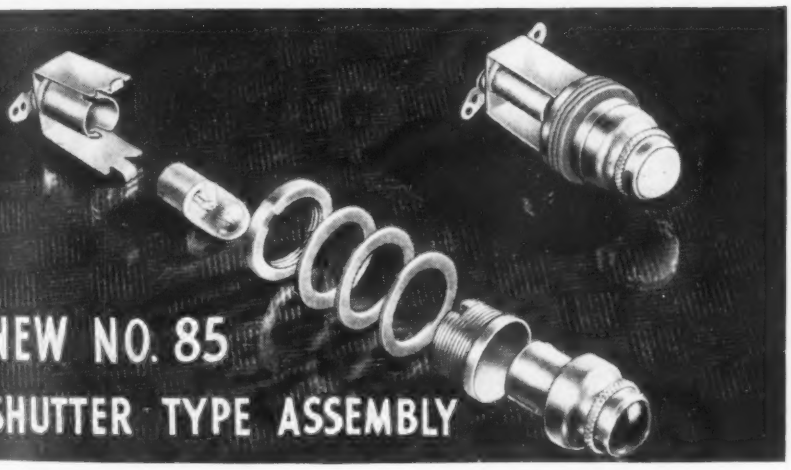

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A LOCKING SLIP-FIT BEZEL is one of the big features of this new and better DRAKE Shutter Type Assembly. It permits instant lamp replacement from front of panel, without tools! Other improvements are complete, *uniform* illumination over entire surface of Jewel, and complete blackout with a quarter (90°) turn to right. Three fibre washers compensate for varying panel thicknesses. This patented Drake Assembly is only one of the many standard and special types we make. As the world's largest exclusive manufacturer, quick deliveries in any quantities are assured. Is our latest catalog where you can reach it instantly?

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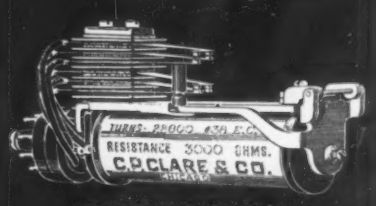

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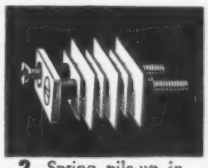

2. Spring pile-up insulators of heat treated Bakelite which permit punching without cracks, have minimum cold flow and low moisture absorption content. Assembly locked together under hydraulic pressure. Withstands heavy breakdown tests.

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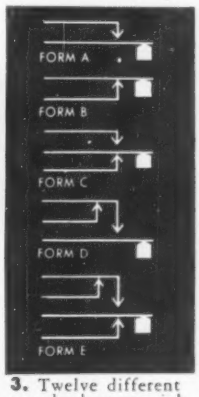

3. Twelve different standard or special types and sizes of contacts can be furnished. Contacts are overall-welded to nickel silver springs. Sizes range from .062" silver, rated one ampere, 50 watts, to .1875" tungsten, rated four amperes, 500 watts.

5. Armature assembly single or double arm. Has stainless steel shaft, operating in a marine brass yoke. Heel piece, coil core and armature are magnetic metal carefully annealed. Designed for d.c. service.

6. As illustrated, relay has octal base plug mounting for easy service and replacement. Other mountings, and Bakelite or metal cover, can be supplied.

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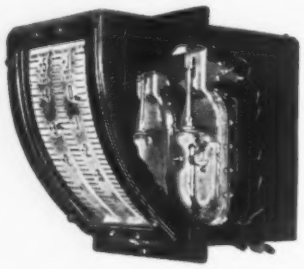

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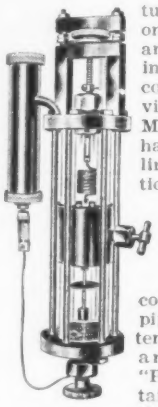
The Month's NEW INSTRUMENTS

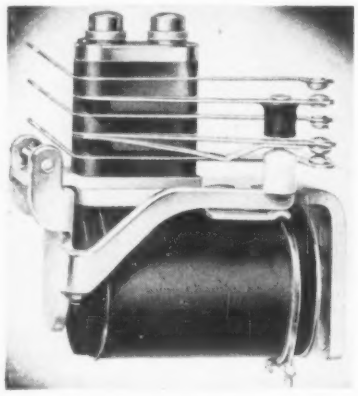
Pressure Pulsation Amplitude Meter

New "Pulsameter" is an instrument for measuring the differential pulsation amplitude across an orifice meter located near a source of pulsations. Amplitude of pulsations depends on local conditions—number and kind of compressors, piping layout, etc. Special tests conducted under the supervision of joint A.G.A.-A.S.M.E. Orifice Meter Committee have established maximum limits of differential pulsation amplitude (as measured by the "Pulsameter") versus meter differential under which accurate measurements may be obtained. "Pulsameter" is connected to the orifice meter piping and by means of a tension spring adjustment and an indicating light the "Pulsameter" reading is obtained. From this maximum differential pulsation amplitude and the recorded differential reading on the orifice meter, it can be determined whether or not accurate measurement may be obtained under the pulsation condition existing in the orifice meter installation.—*The Refinery Supply Co., 621 East 4th St., Tulsa 3, Okla.*



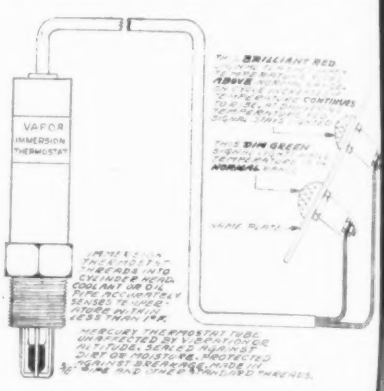
Telephone Type Relays

New "Model TSU" for bottom mounting (illustrated) is one of smaller units in a new line of telephone type relays. Though designed for crystal switching, it is suitable for various h-f. plate circuit and general utility applications. Contact arrangements can be supplied normally open, normally closed, s-p.d-t. or in any two combinations. Contacts will carry 2 amps at 24 volts d.c. and 115 volts a.c. non-inductive load. Coil resistances are available from a fraction of an ohm to 5,000 ohms. New relays will withstand vibrations up to 10 *G* and meet all standard salt spray and humidity specifications. "Model TSL" for end mounting is similar to "TSU" and both are available with ceramic or Bakelite insulation. Overall dimensions 1¼" long, ¾" deep and 1½" high. (Height includes maximum number of contact arrangements.) Weight 1¼ oz.—*Dept. T., Allied Control Co., Inc., 2 East End Ave., New York 21, N. Y.*



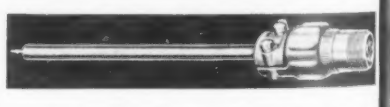
Temperature Warning Signal

New "Telatemp" is a visual warning signal system which intermittently flashes red when temperature starts to rise and constantly flashes red above danger point. It is available for any temperature range from −16°F. to 500°F. for use in oil, Prestone or other liquids or gases. System consists of an immersion-type mercury thermostat connected to a red and a green signal. Green is "on" while the temperature is in normal zone; red signal lights intermittently when temperature rises above normal zone. Duration and frequency of "on" periods of red light indicate rate at which temperature rises; at danger point, red light remains on continuously. Among applications: cylinder-head coolant, engine lubricant, etc. Various standard pipe-size connections are available.—*Vapor Car Heating Co., Inc., Railway Exchange, Chicago 4, Illinois.*



Aircraft Fire Detectors

New "Continuous Type" (illustrated) and "Unit Type" fire detectors for aircraft use are announced. Continuous type comprises copper-plated 7/32" fusible alloy tube containing inorganic insulating beads which support a conductor-wire. Minimum bending radius, 1½"; max. length, 7½". Flame causes tin alloy to melt (m.p. 350°F.), filling spaces between adjacent beads and completing circuit between conductor-wire and grounded tube, to actuate signal light or other alarms. "A false alarm will not occur from an ordinary back-fire." This detector is said to have been thoroughly tested by aircraft mfrs. and gov't agencies. "Unit Type" consists of "Thermoswitch" (see *Instruments*, July 1938, page 176; Dec. 1940, page 382; April 1941, page 87; Sept. 1942, page 377) in which expanding shell separates two silver contacts. Contacts may be arranged either to open or to close circuit on temperature increase. This unit will withstand repeated temperatures of 2,000°F without damage or change in the calibration point, may be used in conjunction with Continuous type for isolated spots. Weight approx. 3 oz. (depends on type). Calibration point, 350°F; response time, 1 to 4 seconds with 2000°F. flame.—*Fenwal, Inc., 6 Pleasant St., Ashland, Mass.*



Porcelain Frame Thermometer

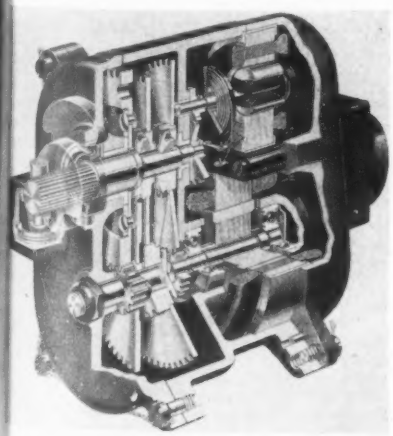
New thermometer, designed for use chiefly in the petroleum field to determine temperatures of liquids in tank cars and other containers, has its frame made of porcelain. Number of parts has been reduced from fourteen to four; and weight increased from 4 oz. to 1 lb. Greater weight permits thermometer to sink freely in viscous liquids. Frame, handle and cup are all in one piece. Tube is attached to frame with two Monel metal bands. Units are available now in temperature range of 0 to 160°F. with a red-liquid-filled tube graduated in single degrees, but other ranges can be made up, to a top limit of 700°F., or even higher if necessary. — *H-B Instrument Co., 2502 North Broad St., Philadelphia 32, Pa.*

Oil Type Capacitors

New "EC" oil type "Capacitrons" are designed as standard components to replace many specials used in production of war equipment, are manufactured in several capacity ranges with d-c. working voltage ratings from 600 to 1,500 to meet U. S. Signal Corps and Navy Specifications. Units are locked on chassis by means of a solid nut and lockwasher through a single hole to clear the ¾" × 16 threaded Bakelite neck. This neck is lock-spun into the extruded, insulated metal container, making possible a 100% hermetic seal. Dimensions of 3-mfd and 4-mfd. size units are 1½" diameter × 4½" height. —*Capacitrons, Inc., 318 West Schiller St., Chicago 10, Illinois.*

Electrical Servomotors for Aircraft Control Systems

Announcement is made of development of a series of aircraft servomotors for application where positive straight-line or rotary motion with or against opposition is required. It is said that, in conjunction with Autosyn transmitters and amplifiers, all interconnected, control systems can be designed to specific applications to provide



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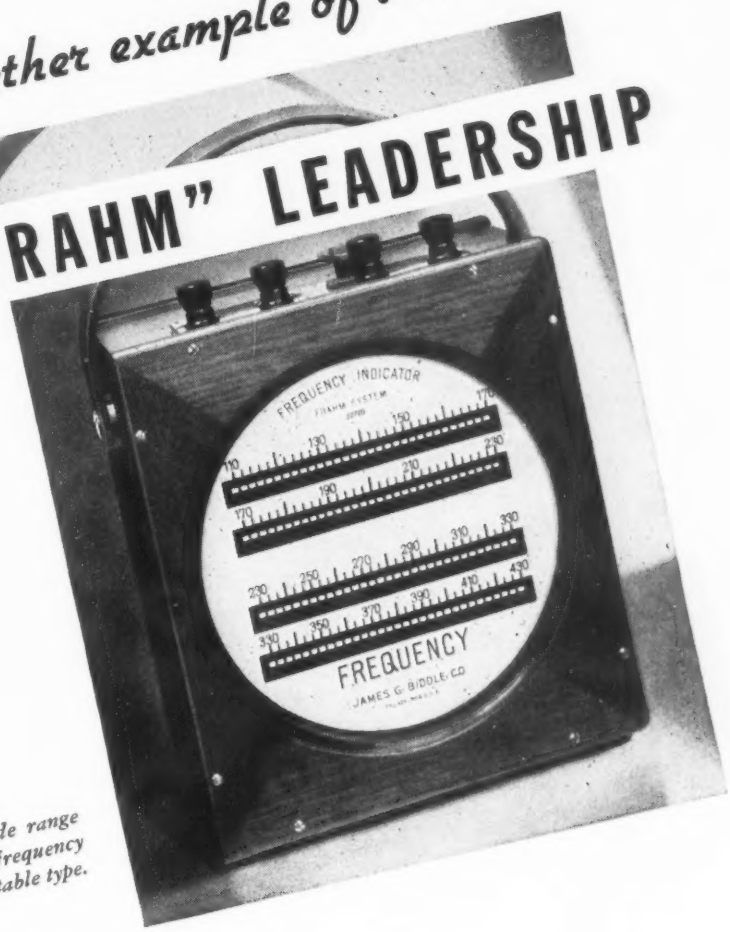

Special wide range "Frahm" frequency meter portable type.

One job we were recently asked to perform was a tough one; namely, to design and build a special wide range portable frequency meter that would indicate from 110 to 430 cycles per second. Furthermore, it was required that simultaneous readings be obtainable at 2 or more points on the scale. . . . The instrument shown above is the successful answer to this unusual problem.

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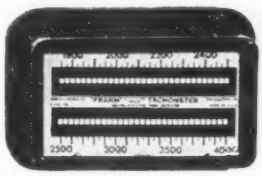

"FRAHM" VIBRATING-REED TACHOMETERS . . .

Operate on the same unique principle as Frahm Frequency Meters except that reed vibration is produced by direct mechanical contact instead of electrically. Available in stationary and portable types . . . for use on turbines, generators, motors, blowers, centrifugal pumps, Diesel-electric installations, etc. Various ranges from 900 to 30,000 r.p.m. Write for Bulletin 1590-I.

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PROBLEM

1. Simulate an altitude of 30,000 feet at room temperature.
2. Return to atmospheric pressure and hold at 40° C. and 30% relative humidity for 30 minutes.
3. Change to 95% relative humidity and hold constant for 1 hour.
4. Return to 30% relative humidity and hold for 30 minutes.
5. Hold for 12 to 18 hours at 25° C. and 50% relative humidity.
6. Reduce to –65° C. and hold for 1 hour.
7. Simulate 55,000 feet altitude at no change in temperature.
8. Return to +70° C. and atmospheric pressure and remain constant for 2 hours.
9. Return to ambient conditions.

Answer

Model RAC 2AA with humidity attachment and a pressure range of from sea level to 70,000 ft., solved this problem with ease. A cross ambient control prevents overshooting at humidities and temperatures close to room conditions.

Send your test problems to American Coils Co., and see if they are not covered by standard equipment. If not, Amcoil's engineers are available for consultation.

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remote automatic and coördinated cont of aircraft main engines, elevator, rudd and aileron control surfaces. Accurate a positive remote adjustments of exact flight functions is said to be obtainab Several motors have been designed to p vide for (1) straight-line motion, (2) tary motion, (3) continuous rotary moti It is said that the use of these servo co trol systems provide a compact lig weight clean installation eliminating chanical and hydraulic linkage with complicated switching, special relays, tentiometers or motor brushes. Current co sumption is said to be comparatively neg gible. Unit illustrated is rated at 45 in pounds torque; output shaft speed 5 r.p.m arm travel 90°; power input 15 watts co tinuous (30 watts underload); 400-cy a.c.; weight 2¼ lbs.—*Technical Data Se tion, Dept. SS1, Eclipse-Pioneer Div., Be dix Aviation Corp., Teterboro, N. J.*

Shock-proof Relay

New "Type 17 AXX" relay is design for rough and tumble airplane use whe the utmost precaution must be take against unintentional operation of contact is said to meet and exceed all specifie requirements for this type of unit: actu tests show that it will withstand accele ation tests of better than 90 *G* or "eight t ten times the *G*-rating of ordinary relays Despite its exceptionally rugged constru tion, new relay is described as small i size and light in weight. Units of this ty are regularly supplied with series coils fo any direct current, or with shunt coils fo use on 12- or 24-volts d.c.—*Struthers-Dun Inc., 1321 Arch St., Philadelphia, Pa.*

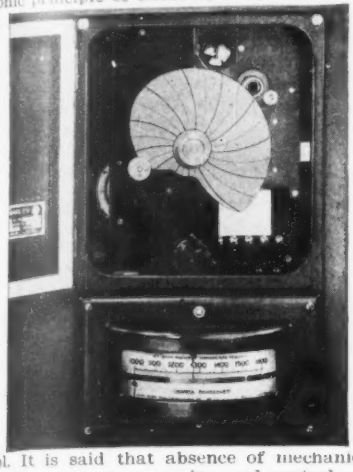
Remote-control Circuit Breaker

New "Klixon D-7229, D-7230 and D-723 remote-control circuit breakers are esp cially designed for aircraft and mobile a plications, as well as other equipment, fo

the operation and control of any remot electrical load. These breaker-relays ind cate circuit operation and can be reset fro a control panel. Unit is said to be "cali brated to precision tolerances," will carr at least 115% of rated current continu ously and will ultimately trip at 125% rated current in an ambient of 25° (77°F.). Actuating element in circu breaker is snap-acting Spencer Disk whic provides a positive make and break. Th disk is unaffected by motion, vibration o shock encountered in aircraft and mobil equipment. Breaker can be had for trip free or non-trip-free operation. In trip-fre arrangement, breaker is free to open i respective of maintenance of handle i closed position. In non-trip-free arrang ment, operator can override action o breaker-relay from control panel. Ne remote-control circuit breakers are avail able in three frame sizes with curre ratings from 35 to 200 amperes for ci cuits up to and including 30 volts d.c. 220 volts a.c.—*Spencer Thermostat Co., Forest St., Attleboro, Mass.*

Temperature-time Schedule Controllers

New line of instruments to provide heating or cooling program is announced. Named "Chronotrols," controllers are built around Wheelco's line of temperature-measuring and controlling instruments employing an electronic principle of effecting temperature con-



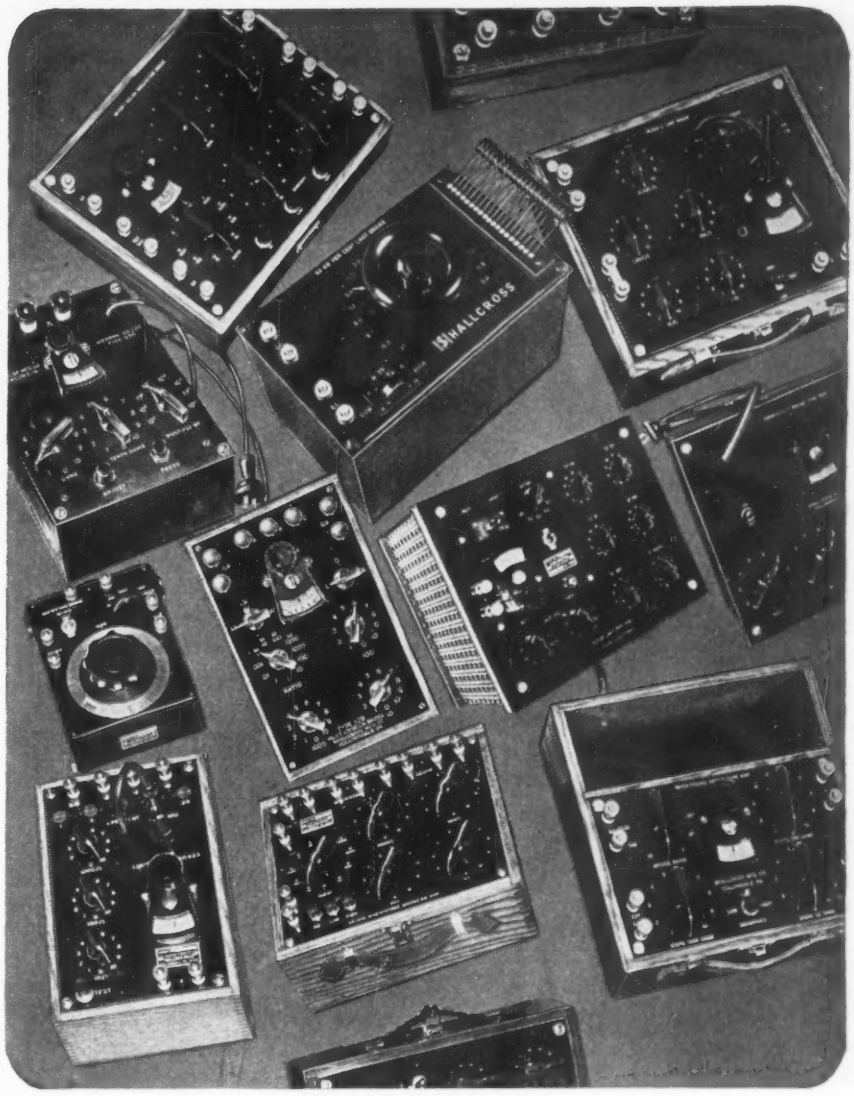
trol. It is said that absence of mechanical linkage between measuring and control sections makes possible instant response of instrument's control unit to changes in temperature at its primary element. Frequency of oscillating current flowing between pick-up coils (mounted on temperature setting lever) is changed when the position of a control flag (mounted on pointer or pen-arm) is changed with respect to the coils by a temperature rise or drop. This frequency change governs the output current of an electron tube commanding fuel valves or switches. "Chronotrols" thus provide completely automatic temperature regulation, apart from the program of temperature changes desired for a given application. Desired temperature cycle is cut on a disk. Rotation of disk by a synchronous motor moves temperature setting lever of control instrument. "Chronotrols" are offered in 25 models, including ten for proportioning control and others for two-position on-off and three-position on-intermediate-off" control for high- and low-temperature applications. Thermometer models are available in recording as well as indicating types.—*Wheelco Instruments Co., Harrison & Peoria Sts., Chicago 7, Illinois.*

Snap-action Sensitive Relay for Use on Slowly-varying Coil Currents

New "Type 79XAX" relay is designed for a variety of electronic circuit applications calling for a highly sensitive unit having snap-action contacts. Contact pressure of this relay remains constant despite slow variations in the coil current in which it is connected. Then, when the coil current reaches a certain point, the contacts operate with a positive snap action. New relay operates on as little as 10 milliwatts in its coil circuit, is recommended for dozens of highly sensitive vacuum tube applications, as well as in detecting overloads at low current levels. Its greatest field of usefulness is said to lie in applications where current varies slowly between various limits, rather than quickly from 0 to rated value.—*Struthers-Dunn, Inc., 1321 Arch St., Philadelphia, Pa.*

Variable Air Capacitors for Electronic Heating

New "Type CX" heavy-duty variable air capacitors are said to be eminently fitted for electronic heating applications; are of sturdy, unconventional design said to offer many advantages for heavy-duty applications. Features include "perfect electrical design symmetry" and built-in neutralization coupled with "extreme mechanical



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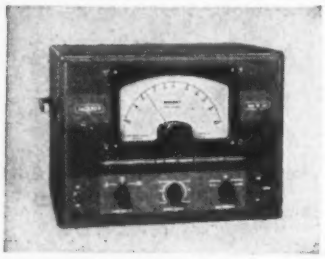

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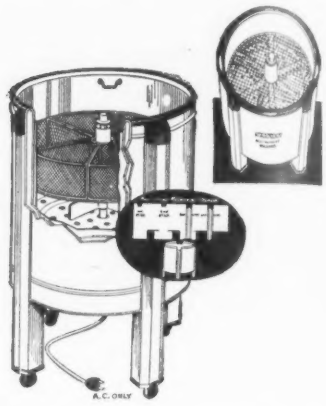
durability." Construction is said to lend itself to built-in mounting of standard inductors in such a way that lead lengths and resulting lead inductance are minimized. New capacitors are available in "almost any required capacity" for electronic heating use up to 5 kw., 12,500 volts.—*Barker & Williamson, 235 Fairfield Ave., Upper Darby, Pa.*

Instrument Washing Machines

New model of "Naxon Portable Electric Washer" is a refined version of the one illustrated and fully described in Jan. 1943



Instruments, page 48. Available also is "Model C-742-B" with thermostatically controlled heating elements. Manufacturer lays stress on fact that user of machine may use any cleaning liquid found most desirable for particular parts being put through cleaning cycle.—*Naxon Utilities Corp., 2101 Walnut St., Chicago, Ill.*

Air Regulator

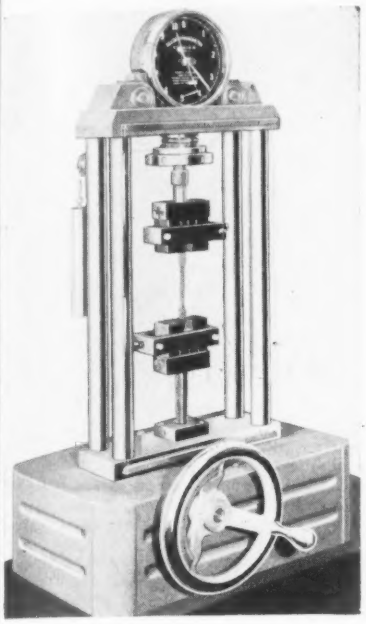
New model of air regulator incorporates improvements to meet critical standards of U. S. Navy. Regulator now is available for installation on air tanks, air lines, equipment and machinery calling for extremely accurate, dependable control and adjustment of air. Working pressures from zero to 140 lbs. can be obtained from any air line or storage tank with initial pressures up to 250 lbs. Pressure is maintained uniformly, once reduced pressure is selected. Simple mechanism is said to assure trouble-free long-life operation, is unaffected by oils and water. Cost is said to be "less than one-third to one-fifth the usual cost of regulators."—*W. R. Brown Corp., 5720-1, Armitage Ave., Chicago 39, Ill.*

High-intensity Illuminator for Industrial X-ray Films

New high-intensity illuminator for viewing industrial X-ray films provides four times illumination heretofore available, facilitates observation of film detail formerly missed when weaker light sources were used, permits finger-tip adjustment to any desired brightness for films of different density, or for different parts of the same film. Intensity is due to use of "Photoflood" lamps which, because of their heat, would curl and damage films, and even crack illuminator, had not manufacturer's, engiglass front of a conventionally-designed illuminator, had not manufacturer's engineers worked out cooling system using a built-in fan to blow air between an inner special heat-resisting glass and an outer flashed opal glass front. Foot-switch control causes lamps to be "on" only when in use, prolongs lamp life and eases strain on eyes of observer. A special feature of new illuminator is an ultra-high-intensity "spot," 3" in diameter, giving four times brightness of large section. Glass front of spot is water-cooled, with light from lamp passing through four inches of water.—*The Kelley-Koett Mfg. Co., Covington, Ky.*

Portable Tensile Tester

New model is announced of portable tensile tester (see *Instruments*, Dec. 1942, pages 535-536 for full description of original model). For majority of tensile, compression, transerse or shearing tests, it is



said that new model will obtain required data more simply and economically than average tester of comparable capacity. Although it starts at 0-250 lbs. and has seven intermediate and interchangeable indicators up to 0-10,000 lbs., it is light in weight (132 lbs.) and 25" tall. New holder-design, for standard V wedge serrated grips, permits rapid specimen insertions and removal. Although hand-driven, tester can be readily motorized and can be had with a metal floor cabinet with specimen space and room and shelf for motorizing.—*W. C. Dillon & Co., Inc., 5410 West Harrison, Chicago 44, Ill.*

Stereoscopic Celestial Navigation Slides for Three-dimensional Effect

"Polaroid Vectographs" are three-dimensional-effect pictures which make it possible to project lantern slides of celestial navigation in full three-dimensional relief, to give the impression of precise wire models suspended in air in front of the screen. So realistic and vivid are these pictures, it is said, that the student can grasp the relationships instantly. For individual

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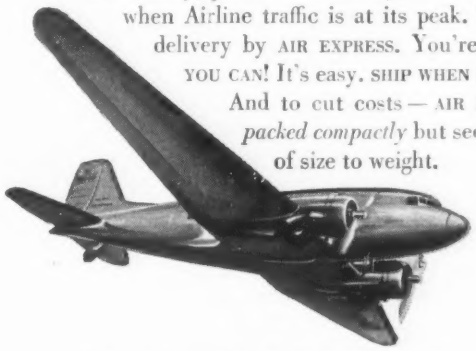

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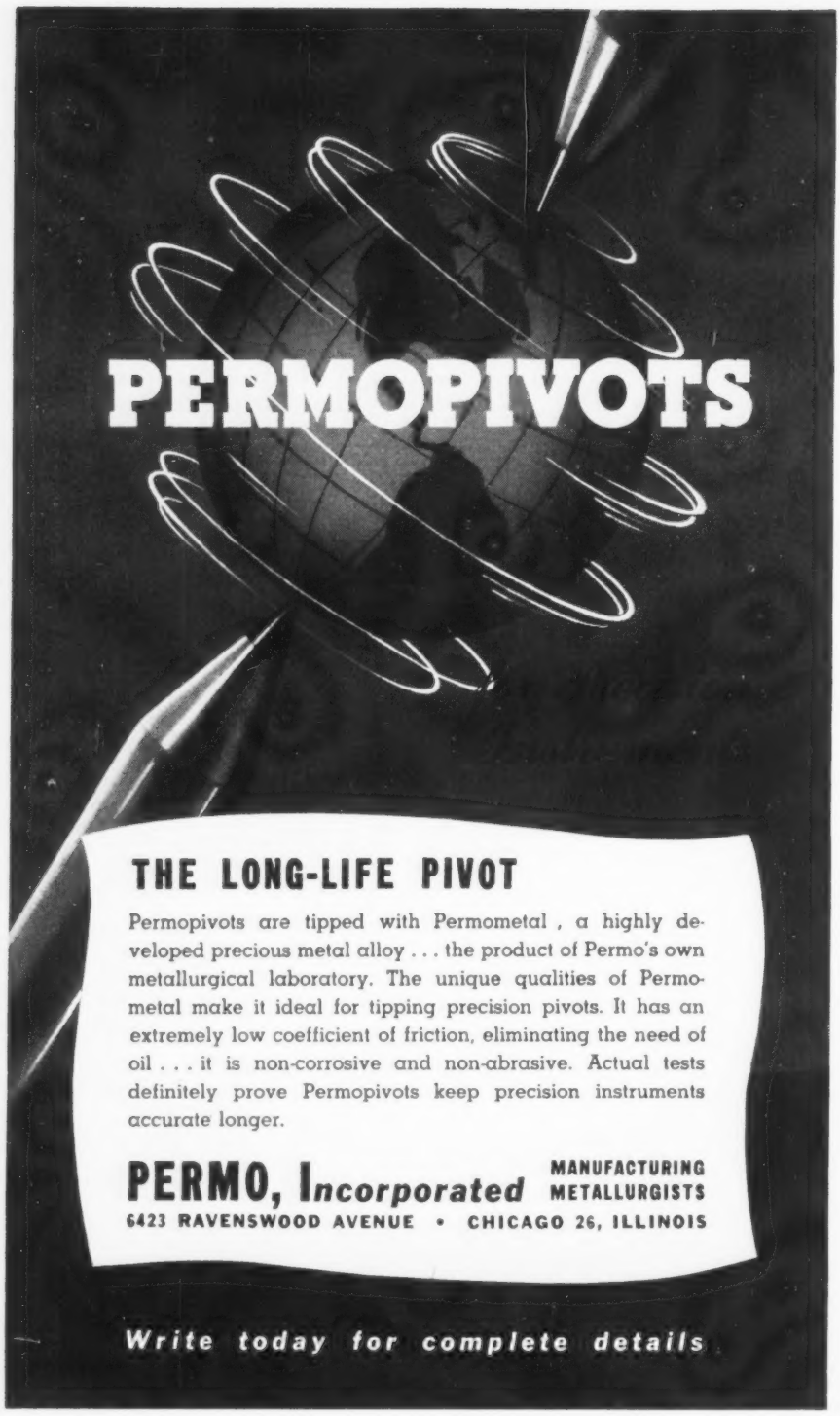
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study, a selection of diagrams is also available in book form, presenting hand-held vectographs, viewed as simply and easily as ordinary pictures. Explanatory text accompanies each diagram. Owing to impossibility of bringing out three-dimensional effect on the ordinary printed page viewed without a pair of polarizing spectacles, the illustration herewith shows neither the slides for classroom use nor the diagrams for individual study, but it shows M.I.T. Professor John T. Rule examining a globe which serves as a photographic model for three-dimensional pictures which he uses in new technique. An instructor walking into the beam of a three-dimensional vectograph of this globe projected on a screen appears actually to be walking into the center of the earth itself. Any standard projector may be used, and no special equipment is needed other than an aluminum-surfaced screen and inexpensive Polaroid viewing spectacles. The technique of preparing three-dimensional projection slides of the heavens is similar to the geometry instruction technique developed by Professor Rule in 1934, when he utilized three-dimensional projected pictures for teaching geometry. A three-dimensional vectograph can be viewed even by a large group of people simultaneously. For example, a navigation instructor can now project a vectograph slide of the Zenith of Greenwich on a screen and know that even those in the back row of the classroom can actually see its precise position in the universe. The vectograph process is the invention of Edwin H. Land and Joseph Mahler. A three-dimensional vectograph is a specially treated plastic sheet. On it, two pictures occupy the same space at the same time. Polarizing three-dimensional viewers unscramble the superimposed pictures to recreate the normal condition of effortless three-dimensional seeing. — *Polaroid Corp., 211 Mass. Ave., Cambridge 39, Mass.*

Porcelain-clad Capacitors

New solder-sealed porcelain-clad "Type FP Inerteen Capacitors" are for high-voltag d-c. applications where space is limited. From 7,500 volts up to and including th 200,000-volt class, capicator elements ar hermetically-sealed in a tubular wet-pro

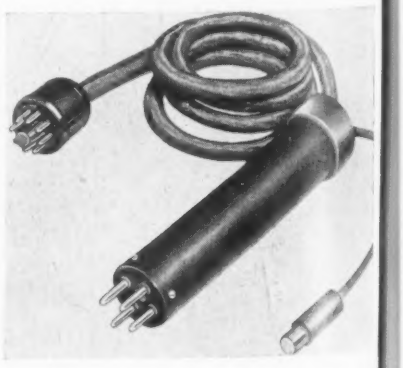
cess porcelain body with solder-sealed en closures. End closures act as capacitor ter minal by connecting element leads at oppo site ends, utilizing the porcelain tube as insulation. Elimination of large metal cas and bushings required by metal-case capa citors minimizes overall dimensions. Large types are furnished with or without cas mounting flanges. Where castings are used capacitors are solder-sealed, then casting are cemented on with mineral-lead com pound.—*Dept. 7N-20, Westinghouse Elec. Mfg. Co., East Pittsburgh, Penna.*

Quarter-million-volt Capacitor

New 0.02-mfd. 250,000 volt unit consists of im pregnated capacitor housed in a wet proces porcelain tube and fille with a liquid dielectric End caps are Westing house solder seal type which act both as t mounting arrangement and terminals. Unit is built for total submer sion for salt water and operation under severest condition. Voltage rat ings range from 750 volts to a quarter of a million volts in single units and can be con nected in series for oper ation up to several mil lion volts. — *Industrial Specialty Co., 1725 West North Avenue, Chicago 22, Ill.*

Multi-pin Plugs

New "CML Production Plugs" are 5" long and 1¼" in diameter, so that handle will project above average transformer capacitor, making it readily accessible. Plugs are made with a heavy steel barrel and are fitted with a wooden handle to permit ready removal from socket. All pins



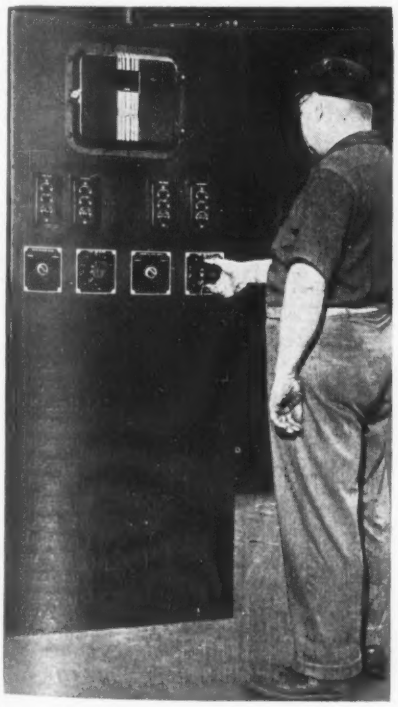
are case-hardened steel, may be replaced when worn or broken. In both octal and loktal plugs, center key extends through in form of a threaded rod to permit cable to be fastened firmly in position without strain on pin connections. A flat head machine screw serves same purpose in other plugs. In addition to octal and loktal types, plugs are available in 4-, 5-, 6- and 7-pin models, small and medium.—*Communication Measurements Laboratory, 116 Greenwich St., New York City.*

"Four-in-one" Dynamotor

New dynamotor, instead of having one or two output voltages, provides four closely regulated voltages, +14½, −150, +300, and (150+300) or 450. It requires four separate commutators, so that problem of taking connections to outer commutators through inner commutators had to be solved. Ordinarily, output voltage of a dynamotor bears a fixed relation to supply voltage. In this case, however, all output voltages are held constant for all normal input-voltage variations. This is accomplished by means of a regulator field which weakens when the input voltage rises and strengthens when voltage drops; regulator utilizes a separate core. Complete armature has four commutators, two cores and four windings; total diameter is 2.8" and length is 11".—*Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.*

Combustion Control System

New "Type P" system of combustion control is said to make available to smaller industrial and municipal power plants a regulation as effective and reliable as maker's "Metermax" system brings to large central stations. Applicable to boilers fired with coal, oil or gas, new system continuously proportions fuel and air to steam demand and, at the same time, controls furnace pressure. To regulate fuel-feed and draft (either forced or induced), system provides a simple electrical balance (using Wheatstone Bridge principle) by which the settings of valves, dampers or vanes are varied in definite proportion to steam demand as directed by a Master Controller. The remaining draft damper or other device is simultaneously regulated by the Furnace Pressure Controller. If operator at any time does not desire full automatic control, he can move any of the drive units from push button stations. Without leaving



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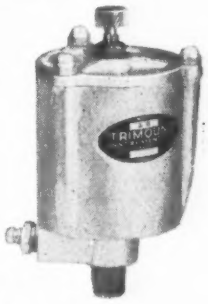

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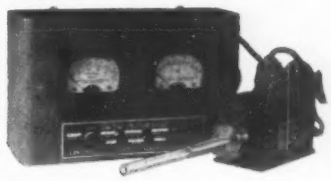

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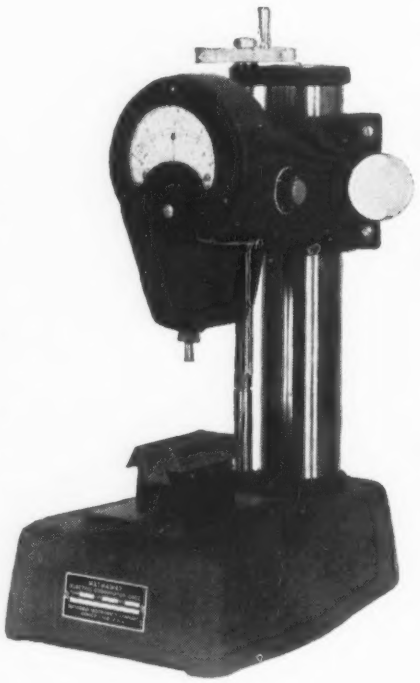

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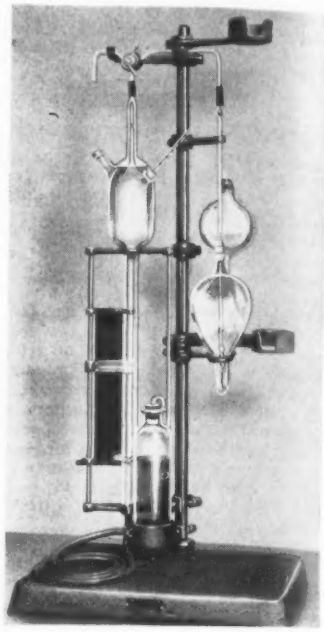
the panel, he can switch from (1) full automatic control to (2) base load control, and regulate air supply from a single push button, with fuel supply automatically following in proper relationship and with furnace pressure automatic. He can, as easily, (3) regulate both air and fuel from push buttons, with furnace pressure automatic. Or (4) he can switch to complete push button control and regulate each drive unit separately from the panel. This independent operation of drive units allows the controllers to be serviced without interrupting boiler operation. Except for drive units, all equipment can be shipped on an easy-to-install panel. Or if preferred, equipment can be mounted on a complete boiler panel —along with draft gages and other instruments. Drive units are connected to panel by simple conduits which any plant electrician can install.—*Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.*

Wide-range Oscilloscope

New 5" "Model 556 Oscilloscope" is equipped with a direct-reading voltmeter for measuring input signal. Sweep generator has a frequency range of 1000 kc., 20 cycles to 1 Mc. Horizontal and vertical amplifiers are practically flat to 2 Mc. The Z-Axis Amplifier, which is useful up to 6 Mc., permits blanking and marking. A special "Comparison Voltmeter" is incorporated to further increase instrument's usefulness and requires no additional equipment to determine value of signal. Deflecting plate connections are available at front panel. All controls are located at front panel and conveniently grouped by functions. New oscilloscope is said to be "a single unit which can do the work of two": for work on higher frequencies as well as standard ones. —*Reiner Electronics Co., 152 West 25th St., New York 1, N. Y.*

Carbon Determinator

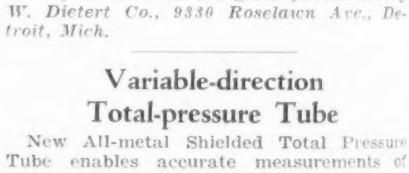
New "Two Minute Carbon Determinator," for rapid total carbon determinations of all metals, incorporates new features said to eliminate much of the human equation. Gas pressure in measuring burette and CO_2



absorption vessel is automatically brought to the same atmospheric pressure, thus eliminating possibility of inaccurate reading due to difference in gas pressure at start and end of test. Gas pressure in measuring burette is precisely brought to atmospheric pressure at time reading is taken. This is accomplished by having burette connected to a U-tube absorption vessel. Liquid level in vessel is brought to an exact fixed hair-line marker on a capillary tube stem of this vessel. This marker is set at atmospheric pressure level and eliminates error caused by leveling by eye between aspirator bottle and burette stem. With this carbon determinator, sample is burned in the combustion tube in a partial vacuum which aids in complete combustion of sample. Improved support gives maximum protection to the glass parts.—*Harry W. Dietert Co., 9330 Roselawn Ave., Detroit, Mich.*

Variable-direction Total-pressure Tube

New All-metal Shielded Total Pressure Tube enables accurate measurements of total pressures to be made in fluids where the direction is questionable. It is said to

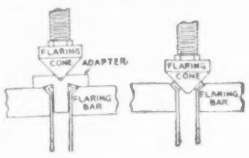


have a range of usefulness in excess of 60° angle of yaw, which is greater than usually required in any particular application. The shield or ferrule of Venturi cross-section is said to "insure the flow of being paralleled to the total-head tube and therefore affords an accurate measurement of the pressure." Among recommended applications are power plant tests, flight testing and wind tunnel models. Units are available in three sizes: ¼", ⅜" (see cut), ¾" outside shield diameter, with any desired length of shank, equipped with standard pressure-line coupling and mounting chuck. Available also in a ½" size is a unit made completely of stainless steel to operate in hot gases.—*The Revere Company, Dep't I, P.O. Box 504, Wallingford, Conn.*

Flaring Tool for Plastic Tubing

New "No. 175-FP Multi-size" flaring tool designed specifically for use with plastic tubing produces approved type double-thickness flare for connecting this tubing with

flare fittings, handles four sizes: 3/8", 1/2", 5/8" and 3/4" outside diameter. While it is designed especially for 0.062" wall tubing, it will also handle 0.031" wall. Flare produced by this tool is called "double" because plastic tubing is folded back at ends



to form a flare with double-thick double-strength walls. This double flare is reported to offer following advantages as compared to ordinary single flare in making joints with larger sizes of plastic tubing: (1) Makes joints having 35% greater resistance to pull-out. (2) Retains its shape after flaring—does not snap back as single flare tends to do. (3) Protects wall of tubing against being squeezed too thin in flaring. Complete tool consists of flaring bar, yoke with swivel cone and four adapters, all furnished in a metal kit.—*The Imperial Brass Mfg. Co., 1200 W. Harrison St., Chicago 7, Ill.*

Vernier Gage Blocks

New "DoAll Vernier Gage" consists of two gage blocks having a precision taper on their mating faces. When taper faces of blocks are wrung together with their taper index marks coinciding, the blocks form a gage block whose height is 0.7000". One block is graduated into ten equal parts between the index graduations. By sliding this block to the right, height of Vernier Gage is increased ten millionths for each graduation; sliding this block to the left, height of Vernier Gage is decreased ten millionths for each graduation. Vernier Gage has a total range of one ten-thousandth plus or minus, thereby enabling dimensions to be made in increments of ten microinches above or below any dimension

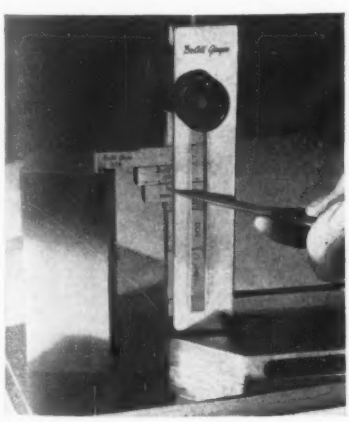


Fig. 1

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MORE ACCURATE, MORE DEPENDABLE FOR PRODUCTION TESTING because:

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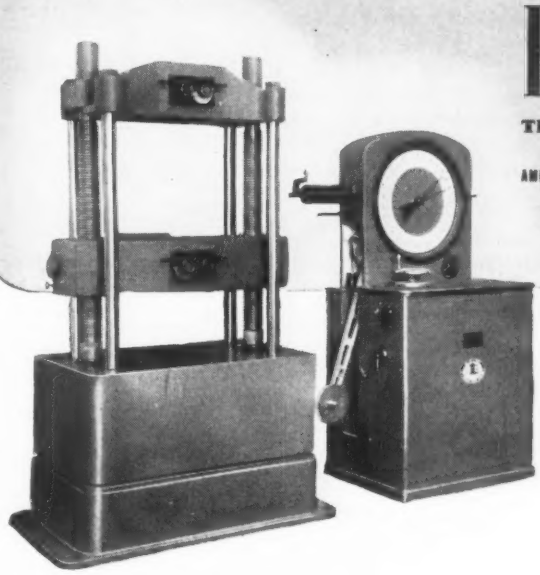

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Jobs of sawing and cutting that are inaccessible to ordinary tools, are now made possible with the recently developed Saw-Gun. It works equally well on wood, plastics, light and heavy gauge metals (corrugated or plain—stainless and monel), castings, rods and other materials. The Saw-Gun saves hours on panel notching and slotting operations, doing work ordinarily requiring the use of several tools.

It is propelled by electric power, compressed air or flexible shaft and provides an efficient portable power-saw or file, that can be carried from place to place.

The Saw-Gun is operated by placing cutting edge of saw blade against work and turning on power. Filing is accomplished in the same manner by inserting a file in the tool instead of a saw blade.

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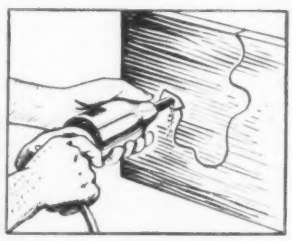
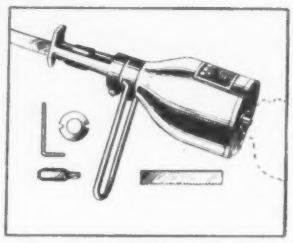


Permits sawing and filing in spots inaccessible to ordinary tools.



Can be directly connected to electric drill, air drill, or flexible shaft.

Y-105

Glass and Transparency Holders for Optical Comparators

Adapters and fixtures are announced for holding glass and transparency charts (made by undersigned company) on optical comparators made by Bausch & Lomb or by Jones & Lamson. Charts are held in correct focal plane and work is speeded up. Fig. 1 shows one of the adapters for use on B&L Contour Measuring Projectors; it is for 10" × 12" charts; others are available for various sizes of square, rectangular and round charts up to 18⅝" × 18⅝".

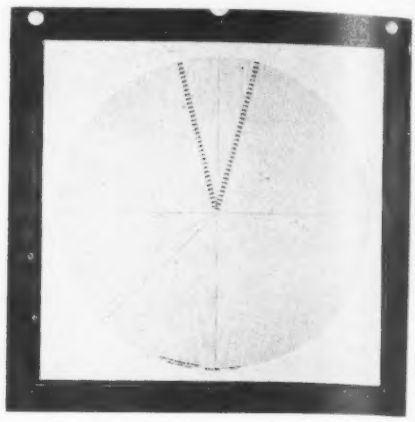


Fig. 1

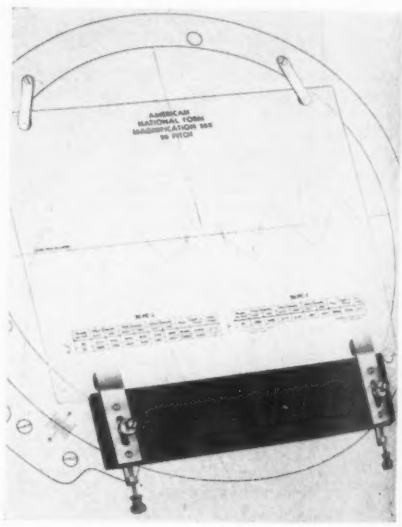
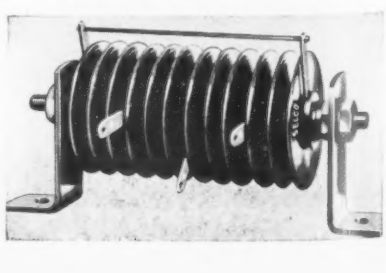


Fig. 2

Fig. 2 shows one of the holding fixtures for use with J&L Comparators: it is designed for holding charts of three standard sizes up to 10½" × 16".—*Engineers' Specialties Div., Univ. Engraving & Colorplate Co., 1919 East 19th St., Cleveland, Ohio.*

Selenium Type Rectifiers

New "Selco" line of power rectifiers is announced. Seven disk sizes ranging from ¾" to 4½" in diameter are available. All units are stated to be moisture-proof and to have permanent characteristics. Assemblies with output up to 1000 amperes can be supplied. Rectifiers are of the selenium



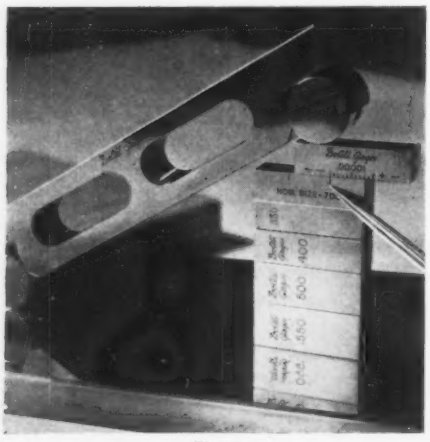


Fig. 2

which can now be made with a standard set of precision gage blocks. New gage thus extends the range of combinations of sizes which can be made with any set of gage blocks by enabling combinations to be made in steps of ten microinches and to the same degree of accuracy as provided by precision blocks. In combination with the Vernier Gage, blocks can be quickly set up to produce "practically all types" of snap gages, height gages (see Fig. 1) and depth gages to millionth accuracy at a fraction of the cost of a special gage. In combination with gage blocks and new Vernier Gage, a precision sine bar (see Fig. 2) can be set to angles within two seconds of an arc. Tool-makers and inspectors can quickly measure any dimension to within ten microinches and it is also claimed that no skill is required in setting the gage, which is wrung together in the same manner as standard gage blocks. — *Continental Machines, Inc., 1301 Washington Avenue South, Minneapolis 4, Minn.*

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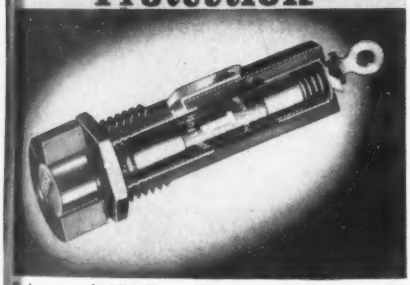

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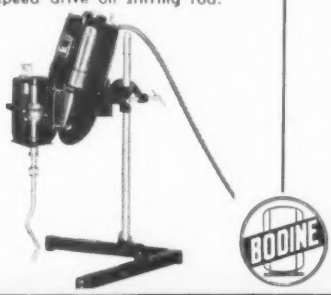

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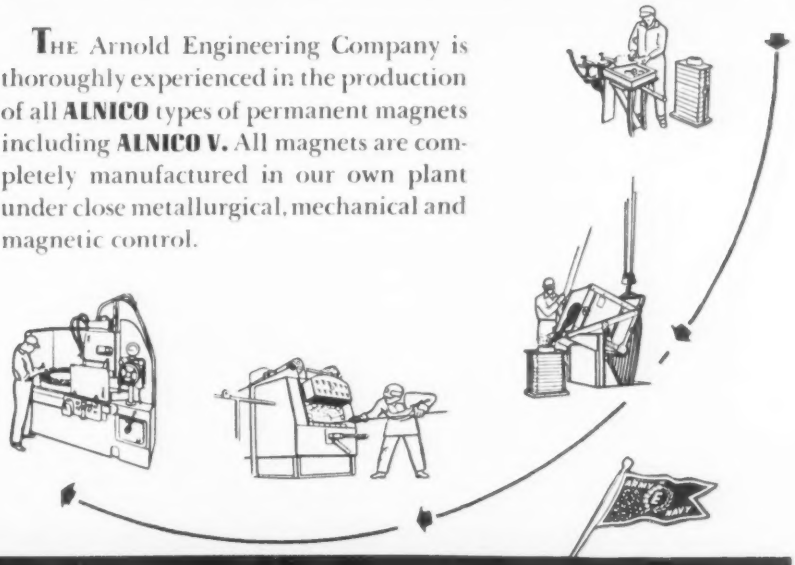

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TYPE BYDK REMOTE BULB MICROTHERM

MICRO SYSTEM FOR PROCESS CONTROL

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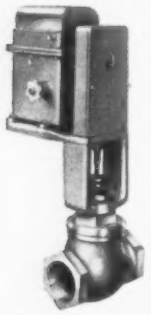

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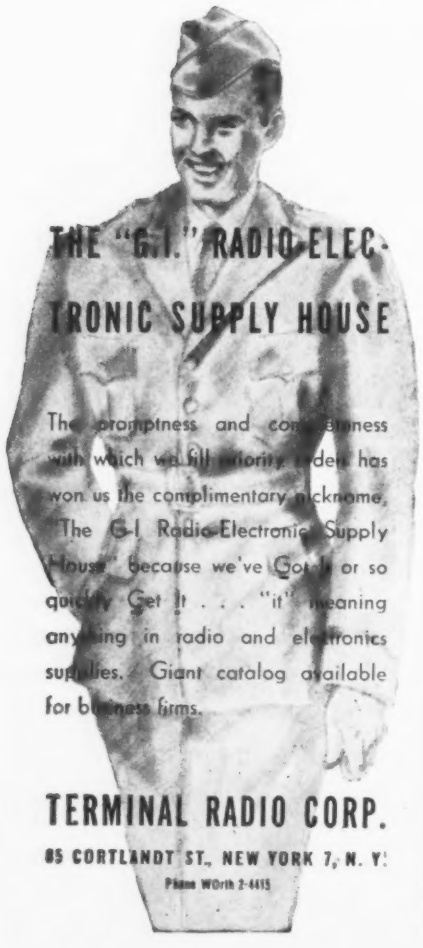

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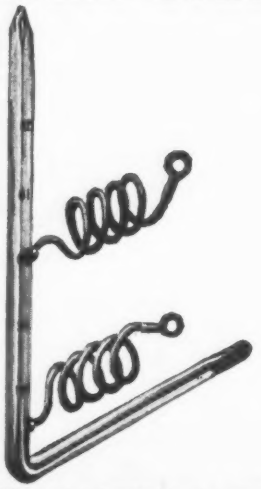

● Sensitivity of a hundredth of a degree is easily attainable. ● Top of mercury column visible at control point (where most important) because electrodes terminate at back of tube. No encircling metal bands! ● Available in angle form (illustrated) or conventional straight form. ● Send for brief, attractive bulletin.

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type and are claimed to offer advantages of high efficiency, high overload factor, unlimited life, maximum output per unit weight and advantageous temperature characteristics. New rectifiers are available for bolt or stud mounting direct to equipment or with mounting brackets as per specs.—*Selenium Corporation of America, 1800 West Pico Blvd., Los Angeles 6, Calif.*

Slide Rules

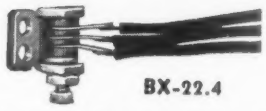
Three new slide rules are announced, one for the professional draftsman, one for the apprentice draftsman or student and also a handy pocket slide rule. All three contain scales A, B, C, D, CI, K, S, L and T. With exception of the apprentice rules they are celluloid-faced (apprentice rule has a painted face). These rules have been produced as an emergency measure to alleviate the shortage. They come with a case and instruction sheet on complete operation.—*Frederick Post Co., Box 803, Chicago 90, Illinois.*

Copper Oxide Rectifiers

Announcement is made of a group of copper oxide rectifiers known as "Coprox". Gold contacts on the copper oxide "pellets", highly adaptable mountings, pre-soldered

BX-22.3

BX-100

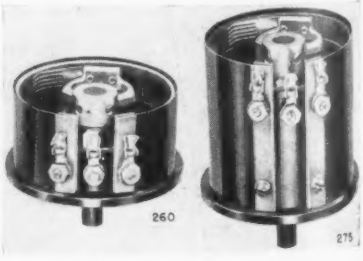


BX-22.4

lead wires, or other arrangements to prevent overheating during assembly of equipment using these rectifiers, are said to be innovations. "BX-100," a center-tap, full-wave rectifier, is completely enclosed in Bakelite and rectifies high-frequency current, operating in special circuits up to megacycles. "BX-22.3" is a double bridge rectifier said to have excellent temperature and temperature-current characteristics. "BX-22.5" is a single half-wave rectifier, "BX-22.2" a full-wave, and "BX-22.4" a double half-wave. Conservative ratings show low forward resistance, combined with high leakage resistance. — *Bradley Laboratories, Inc., 82 Meadow St., New Haven 10, Conn.*

Voltage-dividing Resistors

New "potentiometer" resistors which can operate for 2,500,000 revolutions at 360° continuous rotation in both directions, for 24 hours a day, are among new types announced. In one group ("Types 260, 275, 261,



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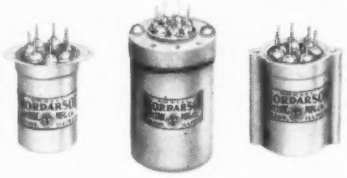

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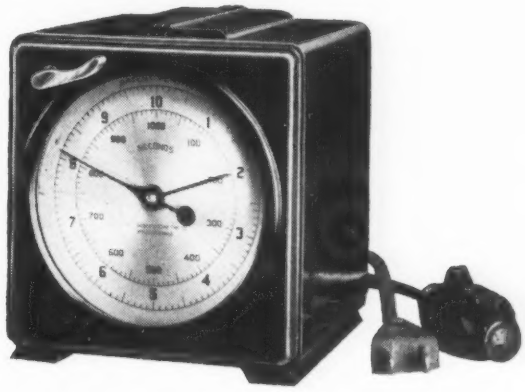

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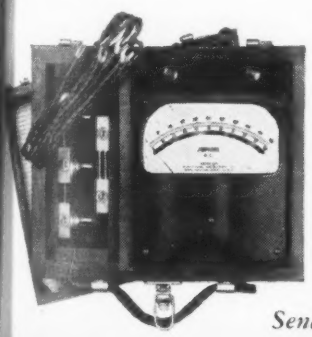

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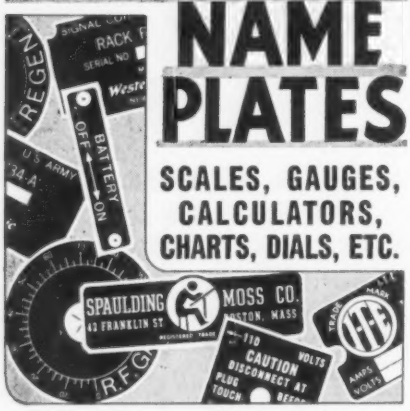

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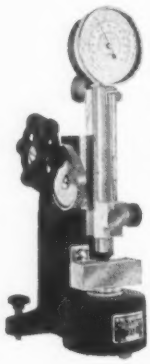

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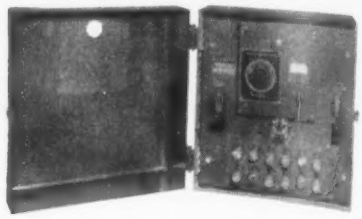
260T and 291") it is said that extremely close tolerances require winding equipment built especially for makers: special machines space-wind resistance wire on a strip of fabric-base Bakelite, then a bonding agent bonds wire to strip, then a protective Bakelite band is placed externally over wire strip and is next bent around and fastened to Bakelite supporting form. In another group ("Types 261, 281, 291, 276, 292 and 296") top wipers are provided for "highest types of accuracy and closest tolerances." These are designed as "Low Operating Temperature Type," as defined by American Standards Ass'n. and it is said that on inspection after 2,500,000 revs they appear to need no adjustments.—*DeJur-Amsco Corp., Shelton, Conn.*

Current Regulator

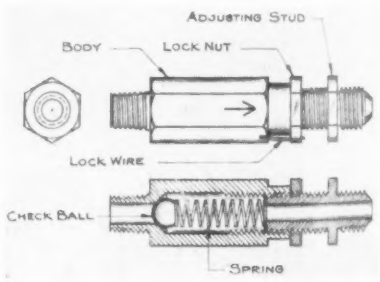
New current-regulating compensator for resistance welding machines is specifically designed to facilitate consistent welds by holding the rms, or true heating value, of the weld current constant for any heat-



control setting, without requiring continual manual adjustment. After predetermined heat-control setting for a particular job has been made, compensator requires no further adjustment, will hold welding current to ±1% "under the same conditions which would cause the unregulated welding current to vary ±20%." An electronic control circuit automatically retards or advances firing point of ignitron tubes used to control welding current, thus holding current constant regardless of line voltage changes or welding conditions. Compensator can be readily mounted on or near welding machine, can be applied to most G-E resistance welding controls utilizing phase-shift method of heat control.—*Electronic Control Section, General Electric Co., Schenectady, N. Y.*

Pressure-relief Valve

New "Model RV-100" (illustrated exactly half size) is announced as a new type of relief valve that permits a straight through flow. It has been developed for the handling of both liquids and gases. It was specifically



designed (and accepted) for controlling fuel pressure in an aircraft application but is offered for a wide variety of industrial applications. It features an external adjustment which permits pressure adjustment of the spring without removing valve from pipe line. It is particularly adaptable for use in a confined space where bends or turns are not readily made. A locknut is used to hold the adjusting stud after adjustment is made. Pressure of locknut serves also as a pressure-proof seal without the use of gaskets. New valves are available in all standard sizes up to 1" pipe size.—*Rogers Products, Inc., 811 Hudson Blvd., Jersey City, N. J.*

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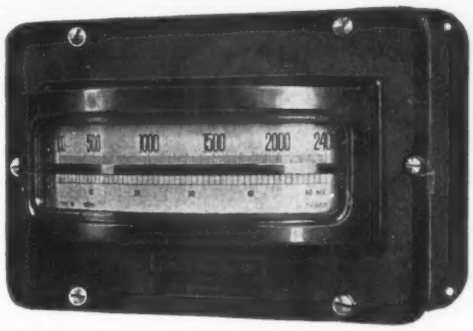

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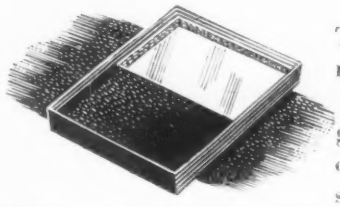

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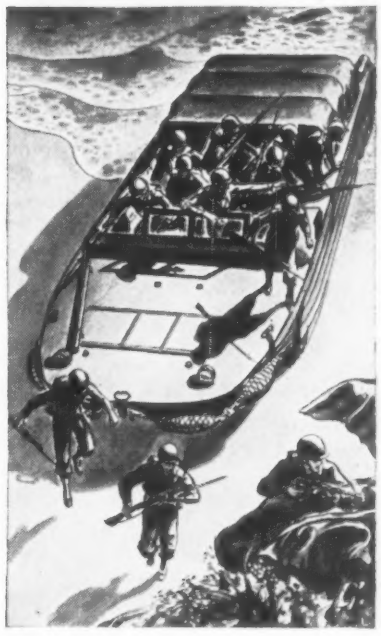

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INSTRUMENT SOCIETIES CALENDAR

City, Society and Secretary			Date	Place	Subject	Speaker
Atlanta	Georgia Society for Measurement & Control	Roger W. Allen, 376 Nelson St., S.W., Atlanta	March 27(A)	Blue Flame Room, Atlanta Gas Light Co.	Infra-red Drying	To be announced
Baltimore	Baltimore Industrial Instrumentation Society	C. B. Willnecker, 6732 Danville Ave., Dundalk, Md.	Mar. 17(D)	Enoch Pratt Free Library	Instruments in Performance Testing of Aircraft	F. C. Phillips, Glenn L. Martin Co.
Chicago	Chicago Society for Measurement & Control	Carl Hope, 2626 W. 31st Blvd., Chicago	Apr. 3(B)	M&M Club, Merchandise Mart	pH Control	Dr. W. N. Greer, Leeds & Northrup Co.
			May 1	To be announced	Electrical Recording Instruments	R. J. Kryter, Esterline-Angus Co.
Gulf Coast	Gulf Coast Instrument Maintenance Men's Ass'n	T. H. Pierson, 3030 Roberta St., Beaumont, Tex.				
Hartford	Hartford Society for Measurement & Control	Stephen J. Zelle, Whitney Chain & Mfg. Co., Hartford, Conn.				
Newark	New Jersey Society for Measurement & Control	N. E. Chance, 14 Glen Oakes Ave., Summit, N. J.				
New York	New York Society for Measurement & Control	H. R. Kalbfleisch, 114-35 No. Blvd., Flushing, N. Y.	Mar. 28(B)	Building Trades Emp. Ass'n, 2 Park Ave.	Electronics: Servant or Fad (with dem't'n)	Dr. P. G. Weiller, Kollsman Instrument Co.
			Apr. 25(B)	Building Trades Emp. Ass'n, 2 Park Ave.	New Optical Tools for Research	Dr. W. B. Rayton, Bausch & Lomb Optical Co.
N. Indiana	Northern Indiana Soc. Measurement & Control	R. W. Schreiner, 4 Waltham St. Calumet City, Illinois				
Philadelphia	Philadelphia Society for Instrumentation	J. E. Gambrill, 1317 Spruce St.	April 19(B)	Engineers Club	To be announced	C. E. Mason, Mason-Neilan Regulator Co.
Pittsburgh	American Society for Measurement & Control	L. M. Susany, c/o Carnegie Institute, 4400 Forbes St., Pgh.	Mar. 27(B)	Roosevelt Hotel	Valve Selection for Automatic Control	J. C. Peters, Leeds & Northrup Co.
			April 24(B)	Roosevelt Hotel	Electronic Measurement & Control	S. L. Burgwin, Westinghouse Elec. & Mfg. Co.
St. Louis	St. Louis Society for Instrumentation	Gus Holubeck, Union Electric Co., Venice, Ill.	March 20(B)	De Soto Hotel, 11th & Locust	Appl. & Maint'ce of Ind'l Instruments	Coleman Moore, Pres. Moore Products Co.
Toronto	Canadian Society for Measurement & Control	T. C. Agnew, Minneapolis-Honeywell Reg. Co., Toronto				

(A)Meeting at 7:30, no dinner. (B)Dinner at 6:30, meeting at 8. (C) Dinner at 7, meeting at 8. (D)Meeting at 8, no dinner.

News of Societies

ATLANTA

Our Past-President, M. Virgil Davis, was the speaker at the January 24th meeting. His talk, "A Trip Through a Modern Steel Plant," was both interesting and instructive.

The newly-elected officers are: Howard M. Baker, *Pres.;* Paul Miller, *Vice-pres.;* Ed Foss, *Treas.;* Roger W. Allen, *Sec'y.*

At the regular monthly meeting on February 28th, a very interesting talk was on Telemetering was given by Mr. R. D. Cowherd, of the Bristol Co. The discussion which followed showed the interest that was taken in this subject.

—H. M. B.

BALTIMORE

The January 21st meeting was held at 8:00 p.m. at the Maryland Academy of Sciences, 2724 North Charles Street, with an attendance of 35 members and guests.

Mr. C. B. Moore, Moore Products Co., Philadelphia, delivered an interesting talk on "The Pneumatic Null Balance System Applied to Industrial Instruments." Slides were used to illustrate his points. A lively question period followed. A rising vote of thanks was given Mr. Moore. The meeting adjourned at 9:45 p.m.

The February 18 dinner meeting had an attendance of 39 members and guests. Mr. Byron M. Dewey opened the meeting and announced the resignation of President F. B. Bevelheimer, who is taking a position as Fuel Engineer of the Algoma Steel Works, Sault Ste Marie, Ontario, Canada. Mr. Dewey, in behalf of the Society, presented Mr. Bevelheimer with a pen and pencil set as a token of appreciation.

At a previously-held Council Meeting Mr. Dewey was elevated to the Presidency, and Mr. E. S. Reisler to the Vice Presidency.

The members and guests then went to the Maryland Academy of Sciences, where a lecture was given by Mr. Kermit Fischer, Fischer and Porter Co., on "The Rotameter and Its Secrets." Members asked many questions which were skillfully answered by Mr. Fischer.

—C. B. WILLNECKER

CHICAGO

The January 3rd meeting was held at Phil Smith's restaurant, Roby, Indiana. As was the case at each meeting this season, a large attendance was on hand to hear R. A. Ackley, Research Engineer for Republic Flow Meters Co., speak on "Comparison of Basic Automatic Control Requirements in Boiler Plants and Process Industries."

—J. A. RIGGS

GULF COAST

Two meetings of the GCIMMA were held in January: On the 12th, at Lamar College, R. L. Nichols, Magnolia Petroleum Co., gave a lecture and demonstration on "Electronics and the Cathode-ray Tube." A Dumont Electronic Switch and an RCA 5" Oscilloscope were used to show current and voltage phase relationships in resonant circuits. The second January meeting was held on the 20th. Mr. Wylie Tomes, Cochrane Corp., gave a lecture on "Flow Meters, Their Construction and Use."

Our new officers are: *Chairman*, T. H. Pierson (Magnolia Petroleum Co.); *Vice-chairman*, G. A. Woods (Gulf Oil Corp.); *Secretary*, C. D. Holt (Gulf Oil Corp.).

—C. D. HOLT

NEWARK

The February 1st meeting produced an attendance of 53. Dr. N. E. Woldman of the Eclipse-Pioneer Div. of Bendix Aviation Corp., spoke on "Metallurgy as it Affects Industrial Instruments." The subject appears at first glance to be somewhat removed from Instrumentation; Dr. Woldman's treatment recognized this by focusing attention on those phases of metallurgy with which instrument engineers come in contact and the problems they encounter.

—N. E. CHANCE

(Telegram) Fifty-six attended February 7th meeting. George A. Martin discussed application of flow meters and W. J. Suber covered installation and maintenance. Both speakers drew on experiences to emphasize sources of error. Numerous questions showed interest in subject.

—ROBERT H. GRAY

NEW YORK

The January 25th meeting was addressed by Dr. S. J. Zand of the Sperry Gyroscope Co., who delivered an informative and amusing talk on the difficult subject of "Airplane Stability and Automatic Flight." The fundamental variables were separated and explained. Dr. Zand's explanation left the group stumped for a moment at the start of the discussion period, and then followed lively questions, which were quickly and skillfully answered.

The first annual business meeting was also held and the newly elected officers are: *Pres.*, C. A. Fairchild; *Vice-pres.*, P. G. Weiller; *Treas.*, E. E. Corbett; *Sec.*, H. R. Kalbfleisch. *Executive Committee*: C. H. Colvin, R. K. Farnham, H. Proske, H. L. Hildenbrand, W. O'Connor.

—H. R. KALBFLEISCH

NORTHERN INDIANA

The January meeting was attended by a fine gathering of 51 men representing some 20 industries throughout the northern Indiana district as well as guests from St. Louis, Detroit and Chicago.

A short business meeting was held by the Executive Board and we regret to report the loss of two of our officers. Mr. L. Johnson resigned as Treasurer to accept a promotion with his company and will be sent to points west. Mr. Charles Bailey resigned as Recording Secretary because his other work leaves too little time. Mr. Clifford Vance and Mr. Louis Lanka were appointed, respectively, to these offices by the Executive Board.

A delicious dinner followed with a choice of fish, chicken or steak.

Mr. L. K. Spink, Engineer in Charge of Flow Measurement, the Foxboro Co., topped off the evening in swell style with his talk

on differential type flow meters. He showed us some correction factors on altitude, latitude, etc., possibly new to many of us. Mr. Spink invited questions from the audience and I am sure everybody left the meeting with more knowledge of flow meters and flowmeter calculations.

—R. W. SCHREINER

PHILADELPHIA

At the January 19th meeting we were fortunate in being able to secure Dr. W. N. Greer, Research Engineer of the Leeds & Northrup Co., who addressed us on "Measurement and Application of pH and Conductivity Instruments."

From an elementary introduction, Dr. Greer developed the factors involved due to process capacity where "detection lag" between the detection instrument and the controlled valve complicated the problem. Dr. Greer floored all of the members during the question session by writing on the blackboard the differential equation for determination of "detection lag."

There was a lengthy discussion on the ability of the glass pH cell to transmit an e.m.f. difference without direct contact between the liquid under control and the buffer solution in the cell.

There were twenty-five at dinner and seventy-two at the meeting, which took about all the chairs available in our meeting room.

At the February meeting we heard a talk on "Electronic Power Applications in Industry" by Mr. F. W. Wentker, who discussed the advantages of high-frequency heating in the molding of thermosetting plastics where a uniform heat is most important. Skin hardening was also mentioned as having the advantage that no quenching was necessary. A short Kodachrome movie followed the talk.

Dinner attendance was 40, while there were 101 at the meeting.

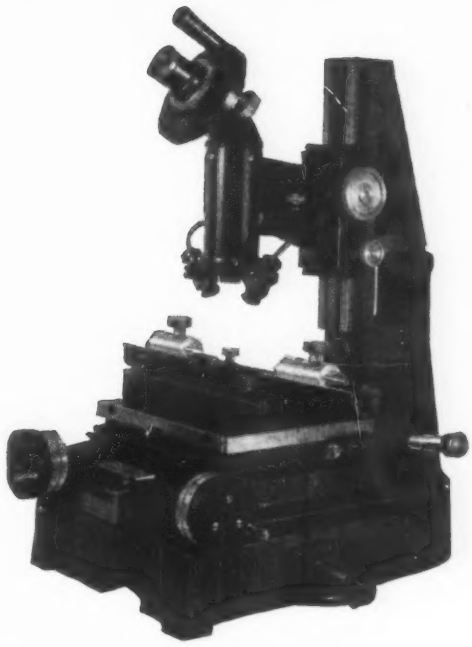
—J. E. GAMBRILL

PITTSBURGH

All records for attendance were broken on February 28: Sixty-four came to the dinner and fifty more came for the meeting to hear C. O. Fairchild, TAG's Research Director, discuss the Theory of Automatic Temperature Control. His discussion was largely mathematical but his conclusion were practical.

A sound film on the manufacture of G-E electric instruments was then shown. It was followed by demonstration of the Brown Continuous-balance Potentiometer and of the TAG Bulk-materials Moisture Meter.

—L. M. SUSANY



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Manufacturers' New Literature

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L-42 **The Capacitator.** Oct. 1943 issue. 16 pages, contains Part I of interesting series of articles on "Superstability at UHF" giving results of investigation, and some theory, made on solenoid type coils for the frequency range of 50mc to 400mc. Also includes an article, "Hints on Servicing Record Changers." Cornell-Dubilier Electric Corp., Hamilton Blvd., South Plainfield, N. J.

L-43 **Coil-Winding and RF Resonance Rapid Calculator.** A new slide-rule type rapid calculator, price 25c. By means of simple settings it is possible to determine with reasonable accuracy values of inductance, capacitance, and frequency components of series or parallel tuned RF circuits as well as inductance, turns-per-inch, wire type, wire size, coil length, and coil diameter for single layer-wound solenoid type RF coils. Accuracy to within approximately 1%. Allied Radio Corp., 833 West Jackson Blvd., Chicago 7, Ill.

L-44 **Thermometers.** Catalog No. 44, 8½" × 11", 52 pages, illustrates and describes etched-stem thermometers for general testing, engineering, industrial and laboratory work. Catalog Number, Range, degree divisions and stem length are given for each thermometer. Several pages are devoted to illustrations in the plant of the Faichney Instrument Corp., Watertown, N. Y.

L-45 **Liquid Level Indicating Equipment for Aircraft.** Application Manual GET-1066, 8" × 10½", 64 pages, was prepared for the aircraft engineers who are responsible for the application of remote-indicating liquid-level equipment. Its purpose is to assist in the selection and application of both the transmitters and indicators. General Electric Co., Schenectady, N. Y.

L-46 **Tachometers.** Folder, 8½" × 11", 4 pages, illustrates and describes portable straboscopic; centrifugal, contact type stationary centrifugal tachometers. Boulin Instrument Corp., New York City.

L-47 **Dials, Scales, Templates, Indicators, Diagrams.** Folder, 8½" × 11", 4 pages, announces a new service for the preparation of the above. Maymer Corp., 10910 Berea Road, Cleveland 2, Ohio.

L-48 **Cannon Signal Systems.** Catalog 311, 8½" × 11", 16 pages. Covers many leading items, describes and illustrates nurses' call systems, doctor's paging systems, registers, time recorders, special switches and lights. Signal System Dept., Cannon Electric Development Co., 3209 Humboldt St., Los Angeles 31, Calif.

L-49 **General Radio Experimenter.** The January issue has two interesting articles: "The Communications Receiver as a Wave Analyzer" and "Continuous In-

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terpolation Methods." General Radio Co., 30 State St., Cambridge 39, Mass.

L-50 **Tools for the Making of New Worlds.** Catalog No. 15, 8½" × 11", 40 pages, lists over 5000 items: tools for precision work, model building, etc. Henry Paulson & Co., 37 S. Wabash Ave., Chicago 3, Ill.

L-51 **Pyrometers—Automatic Control, Recorders, Indicators.** Bulletin DM008, 8½" × 11", 6 pages, describes the Pyromaster potentiometer which has a number of design refinements that make it more convenient to service and use. Bristol Co., Waterbury 91, Conn.

L-52 **Wheelco Comments.** The January-February issue has the following articles: "Wheelco Instruments Prevent Excess Temperatures and Explosions at Perfection Gear" and "Wheelco Thermotrol Regulates Temperature in Tacking Oven of Safety Glass Manufacturer." Wheelco Instruments Co., Harrison & Peoria Sts., Chicago 7, Ill.

L-53 **New Industrial Thermometer.** Leaflet, 8½" × 11", 1 page, illustrates a thermometer in which the wood, brass and other metals difficult to secure have been replaced by porcelain. The porcelain case, handle and cup have been made in one piece. Weight increased from 4 oz. to 1 lb. so that unit sinks freely in viscous liquids. H-B Instrument Co., 2508 N. Broad St., Philadelphia 32, Pa.

L-54 **Ohmite News.** The January issue illustrates the application of Ohmite resistance units to x-ray apparatus. Ohmite Manufacturing Co., 4835 Flournoy St., Chicago 44, Ill.

L-55 **Flash-O-Lens.** Reprint 1-15-44, 8½" × 11", 4 pages, illustrates a number of illuminated magnifiers for accurate inspections, mapping, chart reading, photographic interpretations, finger print reading, etc. E. W. Pike & Co., P. O. Box 4, Elizabeth 3, N. J.

L-56 **Cable Tension Indicator.** Folder, 8½" × 11", 4 pages, describes and illustrates this instrument using the accepted method of measuring cable load by determining the resistance of the cable to bending. Krouse Testing Machine Co., 573 E. 11th Ave., Columbus 3, Ohio.

L-57 **Spectrographer's News Letter.** The January issue has the following articles "Optics of Visible and Infra-Red Spectroscopy" and "Analysis of Aluminum and Magnesium." A. R. L. Dietert Co., 9330 Roselawn Ave., Detroit, Mich.

L-58 **Barometer.** Leaflet B-101, illustrates a precision barometer using the non-lag "zero-gaging" principle. American Paulin System, 1847 So. Flower St., Los Angeles 15, Calif.

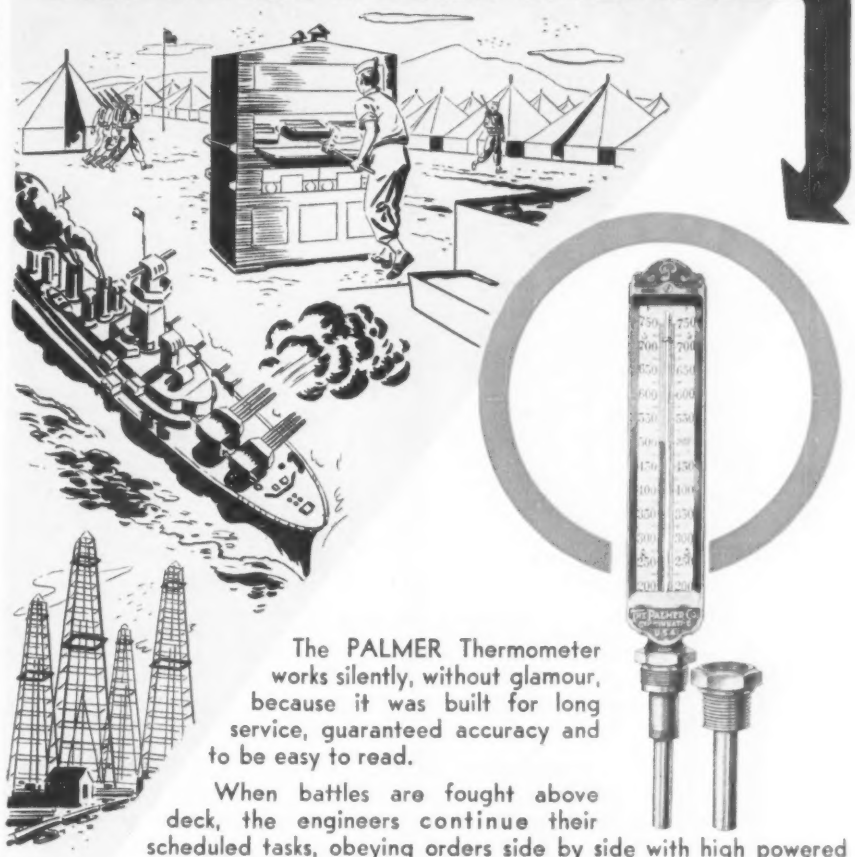
L-59 **Repeated-Scrape Abrasion Tester.** Bulletin GEA-4166, 8" × 10½", 2 pages, describes a machine for testing the toughness of magnet-wire insulation. General Electric Co., Schenectady, N. Y.

L-60 **Anti-Capacity Switches.** Folder, 2⅞" × 5½", 6 pages. Quick change-over, multi-purpose electrical switches having a minimum of capacity between elements are illustrated and priced in this folder. Physical and mounting dimensions also included. Federal Anti-Capacity Switch Corp., 1200 Niagara St., Buffalo, N. Y.

L-61 **Rate of Flow Indicator.** Bulletin No. 163-1, 8½" × 11", 4 pages. Describes new mechanical type of flow indicator which performs the same function as a mercury column, but indicates the rate of flow by means of a pointer (rotation 270°) with respect to a circular scale. This is accomplished by a unique bellows arrangement illustrated by cutaway drawings and photographs. Outstanding features and advantages fully explained in text, and additional drawings give dimensions and schematic hook-up of the indicator. Morey and Jones, Ltd., 922 S. Hemlock St., Los Angeles 21, Calif.

L-62 **Electrochemical Society.** Preprint 83-22, 6" × 9¼", 8 pages. Publication of a paper "The Electrochemist Adopts Automatic Recording Devices Used in Medical Research" presented at the 83 General Meeting. Speeds, speed ranges, and applications of two types of recorders commonly used in Medical Research are presented. Text also includes data on types of chart paper used, and relative merits of each. Gorrell and Gorrell, Chicago Heights, Ill.

Behind the Scene of Action



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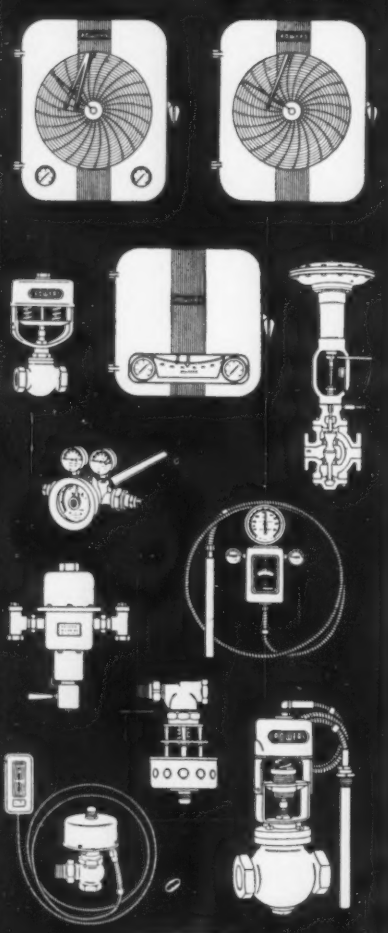

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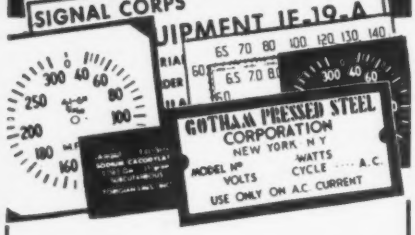

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